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(FIZIOLOGIIA RASTENII)

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THE INFLUENCE OF MICROELEMENTS ON THE SYNTHESIS AND TRANSLOCATION OF CARBOHYDRATES

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(V. L. Komarov Botanical Institute, USSR Academy of Sciences, Leningrad)

A series of investigations [1-8] have shown that boron, manganese, zinc, copper, molybdenum, and aluminum have a positive effect on the synthesis of carbohydrates and also affect their translocation. Shkol'nik [1], Shkol'nik, Makarova and Steklova [3] showed that boron, manganese and zinc have a positive effect not only on the synthesis but also on the translocation of carbohydrates, especially the translocation of sucrose from the leaves into the stems. Later Gauch and Dugger [9], using labelled atoms, also demonstrated that boron enhances the translocation of sucrose.

The question concerning the role of boron in the translocation of sucrose is still of interest to investigators. Recently Sisler, Dugger, and Gauch [10] demonstrated anew the significance of boron in this process. Shkol'nik, Makarova, Steklova and Evstaf'eva [11] showed that the special significance of boron in the formation of reproductive organs, fertilization, and fruit production is its ability to improve the translocation of sucrose from the leaves into the reproductive organs. Steklova [12], Shkol'nik, Steklova, Makarova, Kovaleva and Greshishcheva [13], and Shkol'nik and Greshishcheva [14] presented some evidence which indicates that boron is especially necessary in high doses at high temperatures because boron overcomes the disruption of the synthesis and translocation of sucrose observed in these cases, and that its importance in the formation of roots is associated with its great beneficial effect on the translocation of sucrose from the leaves into the roots.

However, recent literature contains practically no mention of the question raised earlier in some of the literature cited [1, 3] concerning the significance of other microelements, besides boron, such as manganese and zinc, on the translocation of carbohydrates. Furthermore, on the basis of the papers indicated concerned with carbohydrate metabolism and investigations [7, 8] which showed that the abscission of cotton buds, induced to a considerable degree by a disturbance in the synthesis and translocation of sucrose, decreased not only under the influence of boron, but also of manganese, zinc, and copper, one might conclude that other microelements also play an important role in the translocation of carbohydrates. Data obtained by Shkol'nik and Grisheshcheva [14, 15] who made use of labelled atoms, in their work, supported the observation that not only boron, but manganese and molybdenum also promote the translocation of assimilates.

With the object of clarifying this problem, in 1955 and 1956 we set up some experiments with corn on experimental plots at the Microelement Laboratory of the V. L. Komarov Botanical Institute in Leningrad.

In these experiments we studied the effect of five microelements on carbohydrate metabolism: boron, manganese, zinc, copper, and molybdenum, following a presowing treatment of the seeds with them and also during an adequate supply of these microelements to the plant by way of the root system.

The experiments with corn were done with variety liming. The presowing treatment of the seeds lasted for 24 hr in solutions of the following compounds of the microelements: boric acid 0.2 g/l, manganese sulfate 0.5 g/l, zinc sulfate 0.2 gl, copper sulfate 0.04 g/l, ammonium molybdenate 0.25 g/l. Seeds soaked in water for 24 hr served as a control. Compounds of these microelements were supplied to the roots in the following concentrations: boric acid 0.5 g/l, ammonium molybdenate 0.6 g/l, manganese sulfate 1 g/l, copper sulfate 0.2 g/l, zinc sulfate 0.5 g/l. The seeds were planted on May 24th, 1955 and May 22, 1956. The experiments were performed in triplicate.

TABLE 1

The Effect of Microelements on Carbohydrate Metabolism of Corn (in % dry weight)

Variants of the experiment	1955						1956					
	monose	sucrose	maltose fract.	starch	hemicelluloses	total carbohydr.	monose	sucrose	maltose fract.	starch	hemicelluloses	total carbohydr.
Three-leaf stage (total aerial part)												
Control	3,5	3,2	traces	3,3	5,8	15,8	2,5	4,2	traces	3,4	5,1	15,2
H_3BO_3	3,7	3,5	traces	2,2	7,3	16,7	3,5	5,6	traces	3,0	7,1	19,3
$(NH_4)_2MoO_4$	3,9	3,8	traces	1,8	8,1	17,6	3,6	3,1	1,4	2,6	7,9	18,6
$MnSO_4$	3,5	3,4	traces	2,4	7,7	17,0	3,9	2,4	2,8	2,8	7,1	19,0
$CuSO_4$	4,2	4,3	traces	2,4	8,7	19,6	3,7	4,8	traces	2,8	6,4	17,7
$ZnSO_4$	3,9	3,6	traces	2,4	7,4	17,3	3,7	4,4	traces	3,0	6,4	17,5
Six-leaf stage (leaves analyzed separately)												
Control	3,5	2,6	0	2,4	8,2	16,7	3,6	2,2	0	2,1	8,2	16,1
H_3BO_3	3,3	2,8	traces	2,4	9,8	18,3	3,2	2,4	traces	2,6	10,4	18,6
$(NH_4)_2MoO_4$	3,1	3,0	0	2,2	9,3	17,6	2,8	3,7	0	1,9	9,1	17,5
$MnSO_4$	3,5	2,4	0	2,0	9,0	16,9	3,4	3,8	0	1,5	8,9	17,6
$CuSO_4$	4,7	2,5	0,7	1,7	10,1	19,7	4,9	1,9	traces	1,6	10,0	18,4
$ZnSO_4$	2,9	2,6	0	2,0	8,9	16,4	3,1	3,1	0	2,4	7,5	16,1
Six-leaf stage (stems analyzed separately)												
Control	4,5	3,3	traces	3,0	8,1	18,9	4,1	3,3	0	4,4	8,3	20,1
H_3BO_3	5,2	8,5	0	2,2	7,6	23,5	4,5	10,7	0	4,5	10,1	29,8
$(NH_4)_2MoO_4$	6,2	5,8	traces	2,4	8,7	23,1	5,5	5,1	2,5	4,0	10,3	27,4
$MnSO_4$	5,9	5,8	traces	2,5	7,1	21,3	7,9	5,1	0	4,6	9,7	28,3
$CuSO_4$	6,9	7,6	traces	1,8	7,7	24,0	5,6	8,9	0	5,0	9,0	28,5
$ZnSO_4$	7,0	6,2	0	1,8	8,4	23,4	6,8	8,1	0	4,6	9,4	28,9

When the seeds received a presowing treatment with solutions of manganese, copper, and zinc salts germination was accelerated, but when the seeds were treated with manganesese, zinc, and boron development was accelerated. Copper and molybdenum, and especially manganese and zinc, increased the yield of the green tissues and ears of corn. Data pertaining to growth, development, and yield of corn plants from this experiment are given in the paper by Abdurashitov [16].

Samples for the analyses of carbohydrate content were taken at various periods of growth in 1955 and 1956: during the three-leaf stage (entire aerial part present), after the first supplementary feeding of the roots in the six-leaf stage (leaves and stems separately), and in 1955 – after the second supplementary feeding at the beginning of the seed ripening stage (leaves, stems, husks, cobs, and young seeds separately). In 1956, because of a sudden drop in air temperature below zero, it was impossible to obtain samples during the seed ripening period for carbohydrate analysis. The results of the analyses are given in Tables 1 and 2.

From the data in Table 1 it is evident that in the three-leaf stage all the microelements, especially copper and molybdenum in 1955 and copper, molybdenum and manganese in 1956, increased the carbohydrate content of the aerial mass of the corn plants. The starch content decreased due to the effect of the microelements, but in contrast the content of soluble carbohydrates increased.

The data pertaining to the carbohydrate content in the six-leaf stage are interesting. As one can see from Table 1, the stems had a considerably higher carbohydrate content than the leaves. The microelements which had a comparatively small influence on the carbohydrate content of the leaves had a very great influence on the carbohydrate content of the stems: they all increased the monosacharride content, but the increase in sucrose content was especially great; this indicates the favorable effect of these elements on sucrose translocation. The plants which were supplied with boron and copper were especially outstanding in this respect; because of the effect of boron the sucrose content of the stems increased by two and one-half times in the 1955 experiments; because of the effect of copper the sucrose content of the stems increased by two and one-half times in 1955 as well as in 1956.

From the data presented in Table 1 it is evident that during the period when the content of soluble carbohydrates

TABLE 2

The Effect of Microelements on the Carbohydrate Metabolism of Corn During Seed Ripening (in % dry weight)

Variants of experiment	Monoses	Sucroses	Maltose fraction	Total soluble carbohydrates	Starch	Hemicelluloses	Total carbohydrates
Leaves							
Control	4,1	2,3	0	6,4	3,4	13,5	23,3
H_3BO_3	1,3	1,7	traces	3,0	3,2	13,7	19,9
$(NH_4)_2MoO_4$	3,0	0,9	1,7	5,6	3,9	13,7	23,2
$MnSO_4$	2,4	2,2	1,2	5,8	5,4	13,9	25,7
$CuSO_4$	2,3	3,1	traces	5,4	3,0	11,6	20,0
$ZnSO_4$	2,0	2,0	traces	4,0	3,0	12,2	19,2
Stems							
Control	11,7	8,6	traces	20,3	2,3	5,4	28,0
H_3BO_3	6,9	5,5	traces	12,4	3,1	4,9	20,4
$(NH_4)_2MoO_4$	9,9	4,7	traces	14,6	1,5	7,3	23,4
$MnSO_4$	7,5	6,6	traces	14,1	2,0	7,3	23,4
$CuSO_4$	13,8	6,9	traces	20,7	2,8	8,2	31,7
$ZnSO_4$	6,2	11,3	0	17,5	2,0	8,4	27,9
Seeds							
Control	12,9	7,8	1,9	22,6	3,7	5,9	32,2
H_3BO_3	14,5	10,5	3,2	28,2	4,5	5,9	38,6
$(NH_4)_2MoO_4$	13,4	12,9	2,5	28,8	5,0	5,7	39,5
$MnSO_4$	13,7	10,3	1,7	25,7	4,1	7,4	37,2
$CnSO_4$	15,6	8,2	4,9	28,7	4,2	7,4	40,3
$ZnSO_4$	15,4	9,9	3,1	28,4	3,3	5,1	36,8
Husks							
Control	11,3	6,7	0	18,0	0,7	13,9	32,6
H_3BO_3	12,7	10,6	0	23,3	2,1	12,0	37,4
$(NH_4)_2MoO_4$	12,3	9,6	0	21,9	1,8	15,8	39,5
$MnSO_4$	12,7	8,9	0	21,6	2,1	15,9	39,6
$CuSO_4$	13,7	12,7	0	26,4	0,9	18,1	45,0
$ZnSO_4$	15,4	13,8	0	29,2	1,7	13,7	44,6
Cobs							
Control	10,1	6,7	traces	16,9	1,4	3,9	22,2
H_3BO_3	11,1	7,7	0	18,9	1,4	4,0	24,3
$(NH_4)_2MoO_4$	11,4	6,5	traces	17,9	2,4	5,7	26,0
$MnSO_4$	10,0	9,5	0	19,5	1,4	9,5	30,4
$CuSO_4$	11,8	9,9	0	21,7	1,6	8,1	31,3
$ZnSO_4$	12,9	8,7	0	21,7	1,6	4,0	27,3
Silks							
Control	11,4	14,5	3,8	29,7			
H_3BO_3	14,8	19,6	0,6	35,0			
$(NH_4)_2MoO_4$	10,9	15,4	4,3	30,6	Not determined.		
$MnSO_4$	14,7	18,0	1,1	33,8			
$CuSO_4$	12,1	14,8	2,1	29,0			
$ZnSO_4$	13,4	12,9	3,2	29,5			

in the stems increased by almost two times because of the effect of these microelements, the starch content remained practically unchanged. The hemicellulose content increased in the leaves as well as in the stems due to the influence of the microelements. The relationships indicated pertaining to the effect of microelements on carbohydrate metabolism in the leaves and stems of corn were remarkably clear during both years of the experiment.

An analysis of the data in Table 2 discloses a series of interesting facts. As one can see from the data in this table, at the beginning of the seed ripening stage, in contrast to what was observed in the six-leaf stage, the content of monosaccharides, sucrose, and the total carbohydrates of the leaves and stems decreased as a result of

the effect of all the microelements, with the exception of copper in respect to the leaves and zinc in respect to the stem. This can be explained by the increase of monosaccharide and especially sucrose translocation into the ears during this period as the result of the influence of the microelements. It is apparent from the data presented that the content of monosaccharides, and especially sucrose, in the seeds and husks of the ear increased significantly under the influence of all the microelements. The same phenomenon was also observed in the cobs, with the exception of one instance in the variant with manganese in respect to the monosaccharides, and in one instance with molybdenum in respect to sucrose.

TABLE 3

The Effect of Microelements on the Ascorbic Acid Content and Ascorbic Acid Enzyme Activity of the Corn Leaves

Variants of experiment	1955		1956	
	ascorbic acid content, in mg %	activity of ascorbic acid oxidase, in mg oxidized ascorbic acid, in 1 g fresh weight	ascorbic acid content, in mg %	activity of ascorbic acid oxidase, in mg oxidized ascorbic acid, in 1 g fresh weight
Control	86	4.5	69	0
H_3BO_4	128	5.5	80	0
$(NH_4)_2MoO_4$	137	4.5	109	0.8
$MnSO_4$	143	4.6	102	0
$CuSO_4$	111	7.1	125	2.4
$ZnSO_4$	104	4.3	122	1.3

TABLE 4

The Effect of Microelements on Respiration and the Activity of Oxidizing Enzymes in Corn Leaves

Variants of experiment	1955			1956		
	activity of polyphenol-oxidase, in ml 0.01 N KIO_3 per 1 g fresh weight	activity of peroxidase, in ml 0.01 N KIO_3 per 1 g fresh weight	rate of respiration, in mg CO_2/ hr/ 1 g fresh weight	activity of polyphenol-oxidase, in ml 0.01 N KIO_3 per 1 g fresh weight	activity of peroxidase, in ml 0.01 N KIO_3 per 1 g fresh weight	rate of respiration, in mg CO_2/ hr/ 1 g fresh weight
Control	0.8	12.6	1.3	0	4.8	1.0
H_3BO_3	1.0	16.6	1.7	0	6.6	1.4
$(MH_4)_2MoO_4$	1.0	12.8	1.4	1.8	9.4	1.2
$MnSO_4$	3.2	19.2	2.0	4.6	8.2	1.4
$CuSO_4$	0.7	18.4	1.1	2.0	10.8	1.3
$ZnSO_4$	1.8	17.2	1.7	3.6	11.4	1.6

It is obvious that the cob and husks of the ear and especially the silks are characterized by a very high content of soluble carbohydrates, this indicates that these are unique storage organs for carbohydrates, but the carbohydrates are rapidly translocated from them as soon as the seeds begin to ripen. It is interesting to note that the silks have an especially high soluble carbohydrate content, especially sucrose. Shchukina [17] also referred to this in his work. Of the microelements which had a favorable effect on the increase of sucrose content in the silks boron, manganese, and to some degree molybdenum were outstanding, whereas all the microelements, with the exception of molybdenum, increased the monosaccharide content.

The data presented in Table 2 indicate even more clearly than the data in Table 1 the exceptionally great role of the microelements studied in the translocation of carbohydrates, especially sucrose.

How can such a great favorable effect of all five of the microelements on the translocation of carbohydrates be explained? Up to the time when only the beneficial role of boron in this process was known, some investigators [18, 9] visualized the cause of this phenomenon to be the ability of boron to form complexes with the sugars which were distinguished by their greater mobility. When not only boron, but also such microelements as manganese, copper, and zinc, well known for their important role in the oxidation-reduction processes, appeared to have a beneficial effect on the translocation of carbohydrates in our experiments, we came to the conclusion that one of the causes of this beneficial effect on the translocation of carbohydrates should be sought in the effect of the microelements on the activation of the oxidation-reduction processes.

Kursanov and Turkina [19, 20] showed that the cells of the conducting tissues are characterized by a very high respiration rate which considerably exceeds the respiration rate of the remaining leaf tissues, and that sucrose translocation is accompanied by a further increase in the respiration of the conducting tissues; this indicates that a considerable amount of energy must be expended during the movement of one mulecule of sucrose in the sieve tubes. According to Turkinaand Pubinina's data [21], the respiration in the fibrovascular bundles is accomplished to a considerable degree at the expense of the iron containing oxidizing enzymes.

In order to explain the effect of those microelements which accelerate the translocation of carbohydrates on the rate of respiration, the activity of oxidizing enzymes, and the content of ascorbic acid which is an important component of the oxidation-reduction system, we performed the following investigation on the corn plants of this experiment in 1955 and 1956. The following oxidizing enzymes were studied: polyphenoloxidase, peroxidase, and ascorbic acid oxidase. The data obtained are given in Tables 3 and 4.

As Table 3 shows, there was a considerable increase in ascorbic acid content as the result of the influence of each of the five microelements, especially due to the effect of manganese and molybdenum in 1955, and copper and zinc in 1956. The activity of ascorbic acid oxidase in 1955 was considerably higher than it was during the same phase in 1956. Apparently, in this case, the variation in temperature conditions from year to year also had an effect. The greatest activity of ascorbic acid oxidase was observed in the variants with copper and zinc.

Our data concerning the beneficial effect of boron, manganese, copper, and molybdenum on the synthesis of ascorbic acid and on the increase of ascorbic acid oxidase acivity agree with the data of other investigators [22, 23].

Table 4 contains data pertaining to the effect of the microelements on the rate of respiration and the activity of polyphenoloxidase and peroxidase in 1955 and 1956.

It is evident from the data presented in Table 4 that there was an increase in the respiration rate and the activity of polyphenoloxidase and peroxidase due to the influence of the five microelements. Boron was an exception; in 1956 it did not increase the activity of polyphenoloxidase.

Our data concerned with the increase of respiration rate and the activity of oxidizing enzymes due to the effect of manganese, zinc, copper, and molybdenum agree with the results of various other investigators reported in the literature [24-28], even though there is contrary data concerning the influence of zinc. Boron, on the other hand, frequently decreases the activity of oxidizing enzymes and the rate of respiration [29-32], especially during certain environmental conditions; for example, following high doses at high temperature when the oxidizing phase of respiration is stimulated too much. In view of the fact that even under the conditions indicated no decrease in translocation of sugars was observed due to the effect of boron, but instead there was an acceleration of translocation [12], the evident conclusion is that the cause of the favorable effect of boron on the translocation of sucrose and and monosaccharides should be sought in the ability of boric acid to form a complex with the sugars which is more mobile, than sugars alone, instead of in its effect on the activity of the oxidation-reduction processes.

As for manganeze, copper, molybdenum, and zinc, their favorable influence on the translocation of carbohydrates is, apparently, associated with more than their ability to increase the rate of respiration which determines the direction of the energy exchanges involved in the translocation of the organic substance. These elements are also known for their ability to form complex compounds with many organic compounds [22, 24], including sugars. The ability of these microelements to form these complex compounds with sugars is, perhaps, also one of the reasons why they have a favorable effect on the translocation of carbohydrates.

SUMMARY

A study of maize indicated that not only boron favorably influenced the translocation of sucrose and monosacharides but also manganese, zinc, molybdenum, and copper. It was concluded that the influence of the latter four elements on carbohydrate translocation was due to their activization of oxidation-reduction processes in plants. Evidence was provided which supports this supposition.

The assumption was made and substantiated that the cause of the positive influence of boron on the translocation of carbohydrates could be found in its ability to form complex compounds with carbohydrates which are translocated with greater ease.

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THE DEVELOPMENT OF CHLOROPLASTS IN POTATO LEAVES IN RELATION TO CONDITIONS OF MINERAL NUTRITION

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At the present time it appears essential to classify the large amount of experimental material available concerning the productivity of plants in order to develop a theory for obtaining high yields of agricultural crops.

Nichiporovich, who has studied the progress of yield increase as the result of the function of the photosynthetic apparatus in plants, has made a successful attack on this problem [1-5]. The primary component of this apparatus is chlorophyll; its biosynthesis, as well as that of other pigments is closely associated with external environmental conditions and reflects the evolutionary development of the plant kingdom on the earth.

On the basis of experimental data one might conclude that the synthesis of chlorophyll is closely related to protein metabolism and oxidation-reduction processes [6-10].

However, in spite of the great advances of physiology and plant biochemistry in the study of photosynthesis, the structure of the plastids both as the apparatus in which chlorophyll is formed and functions, as well as the original "depot" of the enzymes [11], still remains inadequately investigated.

The first investigations of the microscopic structure of the chloroplasts and the distribution of chlorophyll within them were done by Timiriazev [12]. The investigations begun by K. A. Timiriazev on the structure of the plastids were continued by Tabentskii [13, 14] with sugar-beet leaves. This investigator considered that one should regard the chloroplast as a living dynamic system rather than a static part of the cell, and that changes in it as the plant grows are determined by the rates of the biochemical and physiological processes.

The green plastids and the chlorophyll in them are now considered as a living developing organ which changes under the influence of external conditions, and which is characterized by youth, maturity, and senescence. Externally a change in the chloroplasts is accompanied by a change in the color of the leaves. Therefore, the color of the leaves together with biochemical characteristics is one of the indications of the biological conditions of the plastid, as well as of the entire organism.

Using visual changes in the color of the leaves, Votchal [15] proposed a special color scale to indicate the condition of the sugar beet plant. Unfortunately these investigations were not circulated extensively. Furthermore, because of their simplicity they could be of service in agricultural practices.

The accumulation of experimental material concerned with the condition of the plastids and the level of their activity in relation to the conditions of plant development can be very helpful in developing a theory for obtaining high yields. The data from investigations concerning the development of harvests which received some clarifications in A. A. Nichiporovich's investigations (on leaf area, intensity of radiation, energy balance, water relations of the plant, and others) are widely used in calculating the physiological condition of the plastids and chlorophyll in the ontogeny of the plant.

The object of this investigation was to make a study of the conditions of the green plastids in potato leaves at various stages of plant development in relation to the conditions of mineral nutrition.

METHODS

The experiments were performed on the experimental farm of the Zhitomirskii Agricultural Institute during 1953-1956. Three varieties of potato – early, Ranniaia rosa; medium Parnacciia; and late, Voltman – were raised at field conditions (area of the plots 20 m^2) on forest podzolic and chernozem soils using various mineral fertilizers and combinations of them. In addition, observations were also made in the greenhouse (sand cultures). The experiments in the field as well as in the greenhouse were set up in replicates of 3-5.

The following mineral fertilizers were used: potassium chloride, ammonium sulfate, granulated superphosphate, calcium carbonate, and magnesium carbonate. Each type of fertilizer was used individually in single doses and double doses, as well as in combination with the other fertilizers, briefly as follows: 1) control without fertilizer; 2) control + K (KCl 180 kg/hectare); 3) control + N [$(NH_4)_2SO_4$ – 90 kg/hectare]; 4) control + + P (superphosphate 120 kg/hectare); 5) NPK; 6) NPK + $CaCO_3$ + $MgCO_3$; 7) PK. This same design was also used for adding quantities of NPK. Calcium and magnesium fertilizers were added on the basis of 0.5 of the hydrolytic acids of the soil; this amounted to 180 kg/hectare of $CaCO_3$ and 150 kg/hectare of $MgCO_3$ on the weakly podzolic forest soil.

In order to obtain a clearer picture of the effect of the mineral fertilizers we also chose a soil deficient in mineral nutrients. The preceding crop on the forest-podzolic soil (pH = 6) has been buckwheat, and on the chernozem (pH = 6.5) it had been sorghum.

During the growing period visual observations were made on the condition and external appearance of the plant at the time of vegetative growth, flowering, and tuber harvest; phenological observations were made on the growth and development of the potato plants; analytical investigations of the leaves were made; the tuber yield was measured; and the starch content of the tubers determined.

The color and conditions of the leaves were noted during visual observations. During a microscopic examination of the leaves the following characteristics were studied: form and color of the plastids, the condition of the chlorophyll in them, and the number of chloroplasts in the palisade and spongy cells of the mesophyll parenchyma of the leaves.

During each stage of plant development leaves at different levels were picked from 8-10 healthy plants (lower, middle, and upper), small discs 2-3 cm^2 in area were cut from them and macerated by keeping them in a 5% water solution of chromic acid for 10 min. After this treatment the cells in the mesophyll of the potato leaves separated easily; this made it possible to examine them under the microscope more readily and count the chloroplasts.*

A biological microscope containing an ocular with a pointer was used to make the counting of the chloroplasts in the cells easier.

The visible chloroplasts in the macerated cells from the discs of 8-10 leaves were counted at a magnification of 600 ×. These numbers were then used in the calculations.

In the young cells of the palisade parenchyma where the chloroplasts are distributed around the periphery of the cell and are very close together only one-half of the cell surface was examined.

Therefore, in such instances the average number of chloroplasts counted was multiplied by two. In this way it was possible to estimate the number of chloroplasts along the other half of the cell surfaces which could not readily be studied. As for the cells in the spongy parenchyma which are larger but contain fewer chloroplasts, the total number of chloroplasts in each cell was counted by changing the fine adjustment of the microscope.

After the discs had been cut from the leaves, the mid-veins were removed from the remaining parts of the leaves and the leaves were cut into small pieces with scissors made from noncorrosive steel. From an average sample prepared in this way, after it had first been well mixed, two samples were taken: one for determining the water content of the leaves, and the other for measuring the chlorophyll content. The amount of chlorophyll was determined according to Gyotr (see Ivanov [16]), and the amount of water was obtained by weighing the leaves first and then again after they had dried to constant weight in a drying oven at 102°. After the tubers had been

* We wish to thank Prof. A. A. Tabentskii for recommending the use of chromic acid as a macerating agent, and the use of this method.

harvested and the yield measured, the starch content of the tubers was determined by the polarimeter method used by Evers (see Ermakov, et al. [17]).

RESULTS

The color and surface condition of the potato leaves during the growing period varied with the stage of plant development and also depended on the conditions of mineral nutrition (Table 1). During the vegetative stage the color of the leaves was the brightest green and the leaf surface was the glossiest. During the flowering stage yellow streaks were observed, the glossiness of the leaf surfaces in most of the variants had faded, the leaves at the lower levels were yellow and had begun to die. At the time the tubers were harvested the lowest and middle layers of leaves were dead, the remaining leaves in the upper layer had a dull surface and were becoming quite yellow. However, these changes were not the same for all the variants. The plants which had grown in a soil with NPK + $CaCO_3$ + $MgCO_3$ had the darkest green leaves right up to the harvest period. In contrast, the plants which had received just a single dose of potassium fertilizer had leaves which were pale green with traces of yellow. The plants which had grown in soil with just K added looked the poorest. They differed markedly from the others by their yellowing and early cessation of growth. Apparently, during a deficiency of nitrogen the necessary nitrogenous organic compounds do not accumulate in the plant and protein metabolism is soon disrupted.

There were no specific differences observed in the color of the leaves from the different varieties. Soil conditions had an effect on the conditions of the chloroplasts. The development of green plastids was more intensive on the chernozem and the leaves contained more chlorophyll than those from the forest-podzolic soil; this was entirely dependent on the nutrient conditions of the soils.

The structure of the chloroplasts was not constant and varied noticeably at each stage of plant development. The change in the chloroplasts of the potato leaves is illustrated diagrammatically in Fig. 1.

During the vegetative stage the cells of the palisade and spongy parenchyma differed very little from one another in external form.

They were practically spherical in shape and lay close to one another. The entire cell was filled with spherical bright green chloroplasts. The chloroplasts were homogeneous in structure and reflected the light very strongly. It is true that some of the plastids in the cells of the spongy parenchyma were somewhat smaller and did not lie so close to one another. During the flowering stage of marked difference was observed between the spongy parenchyma and palisade cells, both in shape and size as well as in the condition of the chloroplasts within them.

The palisade parenchyma cells were slightly oval in shape and were becoming larger in size. The chloroplasts were also enlarging and were not very closely situated one to another, they were oval in form and had a granulated structure (under the microscope individual darkish nodules were noted along the surface of the chloroplasts – the granules). The spongy parenchyma cells were irregular in form and were almost twice as large as the palisade cells. They contained fewer chloroplasts with distinct granules, the stroma had begun to become hydrated and part of the plastids were disintergrating.

During the harvest period there was disruption of the chloroplasts within the cells of the leaves from the surviving layers; this disruption was most clearly evident in the spongy parenchyma cells. The chloroplasts disintergrated into distinct small granules which were a dull yellowish green and did not reflect the light. The change in the green plastids from layer to layer of leaves occurred in the same sequence as it did in the different stages of plant growth. At the same time that the plastids in the top layer of leaves were developing and were homogeneous in structure, those in the leaves of the lowest layer were disintegrating. However, though the basic types of changes in the plastids during the progress of development were the same in the different potato varieties, at different soil conditions, and under different conditions of mineral nutrition, the duration of these various stages was very different.

In the variety Ranniaia rosa, the development of plastids and their transformation into the granulated conditions occurred in a shorter time than it did in the later varieties. For example, it was noted that the homogeneous plastid structure of Ranniaia rosa lasted, on the average, 35-40 days, but in the later variety Voltman it lasted 45-50 days. Furthermore, the formation of granules in the green plastids of potato leaves from variety Ranniaia rosa began before flowering in the budding stage, while in the later variety Voltman it began at the height of flowering.

TABLE 1

The Effect of Mineral Nutrition on the Condition of Potato Leaves, Variety Parnassiia, the Amount of Plastids and Chlorophyll in Them, and the Yield of Tubers (Forest-Podzolic Soil)

Variants of the experiment	Visual evaluation of leaf color and leaf surface at different growth stages			Number of chloroplasts during flowering stage (top layer)		Accumulation of chlorophyll during flowering state, in mg% (top layer)		Average yield of tubers from one plant, in kg	Starch content of tubers, in %, on fresh weight basis
	vegetative	flowering	harvest	palisade cells	spongy parenchyma cells	on fresh weight basis	on dry weight basis		
Control without fertilizer	Bright green, glossy	Green, almost dull	Lower and middle layers with yellow spots, drying; top layers yellow-green.	49	31	344.0	1953.9	0.496	17.9
KCl	Green, glossy	Yellow-green, dull; lower layer dying	Lower and middle layers dead; top ones yellow-green, dull.	54	37	267.8	1593.4	0.410	13.3
$(NH_4)_2SO_4$	Bright green, glossy	Green, glossy, much vegetative mass	Surviving leaves of the top and middle layers yellow-green.	76	45	299.2	1615.7	0.575	17.0
Superphosphate	Darkish green, very glossy	Without any distinct changes	All three layers green, not glossy	73	48	370.8	2150.6	0.808	18.1
NPK + $CaCO_3$ + $MgCO_3$	Extremely dark green, very glossy	Without any distinct changes	All layers green; leaves compact, surface not glossy.	123	84	386.4	2299.1	1.193	19.8
PK	Darkish green, slightly glossy	Yellow-green, cloudy; lower layer beginning to die.	Many leaves of the top layer with distinct yellowing, not glossy	76	50	125.5	1109.4	0.416	14.4

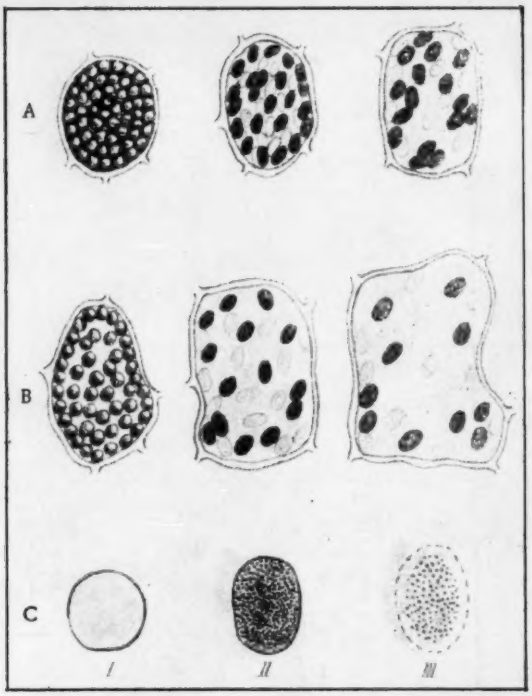

Fig. 1. Diagrammatic representation of the change in the chloroplasts of the palisade and spongy parenchyma cells in potato leaves, variety Parnassiia.
A) Palisade parenchyma cells; B) spongy parenchyma cells; C) chloroplast shape; I) vegetative stage; II) flowering stage; III) at time of tuber harvest.

The condition of mineral nutrition directly affected the length of the developing and ageing period of the chloroplasts. Data pertaining to this are presented in Table 2. The same results were obtained in the field as well as in the green house experiments. The data indicate that a single application of potassium noticeably shortened the viable period of the chloroplasts whereas nitrogen and phosphorus, on the other hand, lengthened this period. A combination of the fertilizers had different effects on the duration of the chlorophyll developing stage. A mixture of NPK + $CaCO_3$ + $MgCO_3$ proved most effective. The juvenile stage (homogeneous) of the green plastids in the potato leaves grown in a soil with this added was quite long and lasted until flowering had ceased and tuber formation had begun. Granulation of the chloroplasts during the flowering stage was seen only in the leaves of the lower layers. In the leaves of the upper layer the homogeneous structure of the chloroplasts was observed even during the harvest stage.

A quite different picture was seen in potato leaves which had grown on soil with PK. This combination of mineral fertilizers had a deleterious effect on the development of green plastids; this expressed itself in the greatly shortened active period of the chloroplasts. In this case the chloroplast granules were observed even in the vegetative stage, and their complete destruction began in the lower leaf layers at the height of flowering.

The life of the chloroplasts from leaves of potato plants which had grown on chernozem soils continued on the average, 8-12 days longer than it did in chloroplasts from leaves of potato plants which had grown on forest-podzolic soil.

As one can see from the data in Table 2, the activity of the chloroplasts in the early variety Ranniaia rosa was about 15 days shorter than in the late ripening variety Voltman. In addition, there was also a difference in the length of the period from the beginning of granulation until the beginning of disintegration (destruction) of the chloroplasts: in the early variety this amounted to 10-15 days, and in the later variety 15-20 days.

The number of chloroplasts in the mesophyll cells of potato leaves is given in Table 3.

One can see from the data in Table 3 that the average number of plastids in the palisade parenchyma cells was considerably higher than it was in the spongy parenchyma cells. The number of chloroplasts increased from the lower to the top leaf layers. The difference between the number of green plastids in the lower and middle layers was considerably greater than it was between the middle and top layers; this is evidence that the physiological activity was greater in the middle and top layers.

TABLE 2

The Duration of the Activity of Chloroplasts in Potato Leaves (in days) in Relation to Conditions of Mineral Nutrition (forest-podzolic soil, middle leaf layer, in round numbers)

Variants of experiment	Ranniaia rosa		Voltman	
	beginning of chloroplast granulation	beginning of chloroplast disintegration	beginning of chloroplast granulation	beginning of chloroplast disintegration
Control without fertilizer	40	55	45	65
KCl	30	40	40	55
Superphosphate	45	60	55	75
$(NH_4)_2SO_4$	45	60	55	75
NPK + $CaCO_3$ + $MgCO_3$	55	70	60	85
PK	25	35	35	50

TABLE 3

The Number of Chloroplasts in the Cells of Potato Leaves, Variety Parnassiia, from Different Levels During the Flowering Stage

Variants of experiment	Lower layer				Middle layer				Top layer			
	palisade parenchyma		spongy parenchyma		palisade parenchyma		spongy parenchyma		palisade parenchyma		spongy parenchyma	
	average number of plastids	± m	average number of plastids	± m	average number of plastids	± m	average number of plastids	± m	average number of plastids	± m	average number of plastids	± m
Control without fertilizer	38	0.54	21	0.93	45	1.54	30	1.03	49	2.16	31	0.91
Superphosphate - 120 kg/hectare	42	1.88	26	0.80	60	1.51	39	1.20	73	1.86	48	0.71
$(NH_4)_2SO_4$ - 90 kg/hectare	54	2.73	33	0.94	63	1.51	38	1.20	76	1.16	45	1.24
KCl - 180 kg/hectare	36	1.07	20	0.57	48	1.75	29	1.09	54	2.27	37	1.27
Control + $CaCO_3$	51	1.85	20	0.73	77	2.06	41	1.64	84	1.44	59	1.32
Control + $MgCO_3$	108	4.18	55	1.20	139	3.56	95	2.10	112	3.63	78	1.58
NPK + $CaCO_3$ + $MgCO_3$	114	3.57	63	3.10	146	3.28	92	2.91	123	3.30	84	2.30
PK	26	1.25	15	0.50	77	2.24	48	0.91	76	1.52	50	0.78

The beneficial effect of magnesium and calcium nutrition expressed itself in the increase of the average number of chloroplasts in the cells from leaves at all levels in the different varieties, as well as on the different soils. In addition to this, the increase in the number of chloroplasts when calcium and magnesium were available was greatest on the forest-podzolic soils. The small decrease in the average number of green plastids in the top layer noted when magnesium and caclium were available as compared with the middle layer was due, apparently, to the rejuvenation effect of magnesium which expressed itself by the significantly lengthened period of chloroplast formation. Because of this extended period of chloroplast formation, the increase in the number of chloroplasts in the leaves of the top layer was till continuing at the same time the process of chloroplast formation in the middle layer had already ceased and only their further development continued.

An increase in the number of green plastids, as compared with the control, was also noted in plants which had grown in soil with a single application of phosphorus, and also nitrogen. A single application of potassium resulted in a decrease in the number of chloroplasts in the leaves from all the layers. The minimum number of chloroplasts was found in potato leaves which had developed in soil with PK (superphosphate + potassium chloride). The number of chloroplasts in the cells of potato leaves varied within a wide range (from 15 to 150) and depended on many factors which affected the physiological condition of the plant. Of these factors the conditions of mineral nutrition were of primary importance.

The dimensions of the chloroplasts were not studied specifically in this investigation. However, during microscopic observations the dimensions of the chloroplasts as well as those of the cells were compared visually. The dimensions of the chloroplasts varied with the maturity of the plant and the conditions of growth; for example, the chloroplasts in the cells from young leaves were of smaller dimensions than those from mature and old leaves. The chloroplasts increased in dimensions during the process of transformation from the homogeneous to the granulated state. Following a single application of nitrogen, phosphorus, potassium, and also a mixture of PK, the leaf cells and the chloroplasts were larger than those in the control plants from a soil without any fertilizer. And on the other hand, the cells as well as the chloroplasts from the leaves of plants grown in soil with magnesium and calcium were small.

The increased number of smaller chloroplasts found in the small cells resulted in a large working surface. The great number of such cells in a single leaf surface brought about a high photosynthetic activity of the leaves. Because of this they appeared a more intense dark green color and had a glossy surface.

In addition to the microscopic examination of the leaves, a number of determinations were made on their chlorophyll content. After the tubers were harvested the yield was calculated and several determinations of the starch content of the tubers were made. Part of these determinations are given in Table 1; from this table one can see that the highest values for yield as well as quality were obtained with NPK + $CaCO_3$ + $MgCO_3$. The figures definitely show that potato plants which contain more chloroplasts and chlorophyll also produced more tubers with a higher percentage of starch. However, the conclusions concerning some sort of relationship between the amount of chlrophyll and yield were not conclusive.

Compared to the control, the yield of tubers from a soil with NPK + $CaCO_3$ + $MgCO_3$ added was high (1.193 kg per plant compared to 0.496 kg), whereas the difference in the amount of chlorophyll was insignificant (2299.1 mg% versus 1953.9 mg%). But the potato plants with calcium and magnesium available developed under more favorable conditions, consequently the photosynthetic activity of the plants was greater. Apparently the productivity of the potato plants is not directly related to the number of plastids and the quantity of chlorophyll present but to the characteristics of the plant during its most active period of growth.

SUMMARY

1. The development of plastids in the leaves was directly related to the biosynthetic potentiality and dynamics of the growth process of the plant organism as a whole and its individual organs. Depending on the stage of growth and development of the potato plant, the color of the leaves changed from dark green with a glossy surface during the vegetative stage to a yellow-green during the harvest period.

2. A complete supply of nutrients with an adequate amount of magnesium and calcium promoted the most intensive development of chloroplasts in the potato leaves and lengthened their periods of activity. A single application of potassium fertilizer, and especially one of phosphorus and potassium, disrupted the normal progress of chloroplast development and shortened their period of activity.

3. The duration of the various stages of chloroplast development varied in the different varieties depending on their maturing period. These stages were considerably shorter in the early maturing potato varieties than they were in the late maturing ones.

4. The number of chloroplasts in the leaf cells depended, without a doubt, on the mineral nutrients available, and varied within a wide range (from 15 to 150 per cell). The chloroplasts in the palisade parenchyma cells were larger than those in the spongy parenchyma cells. The number of chloroplasts in the cells increased from the lower layer to the top layer.

5. A complete mineral fertilizer with magnesium and calcium provided better conditions for the formation of chlorophyll and plastids with greater synthesizing characteristics, consequently the productivity of the potato plants increased.

6. There was a direct relationship between the natural growing changes of the leaves as well as the growing changes of the plant organism as a whole and the progress of plastid formation.

7. E. Votchal's idea pertaining to studying the physiological conditions of the plant as a basis for investigating the color of the leaves should certainly be given attention. Votchal's color scale should be developed further, especially for various agricultural plants, and instructional material for the use of this scale by agricultural specialists should be worked out.

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RESISTANCE OF SUMMER WHEAT TO EXCESS MOISTURE

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There are three zones of excess moisture in the Soviet Union – Southern Non-chernozem belt, the Far East, and Transcaucasus. The periodic occurrence of excess moisture in these zones is a serious threat to agricultural crops. For example, in the Far East, every other year is one with excess moisture and in these years the yield of the most important crop – summer wheat – is lowered by 20-50%.

Despite the great national economic significance of this problem, very few studies have been devoted to the question of moisture-resistant plants, in contrast to the broad literature on resistance to aridity.

Since it is not possible in a short paper to give an account of the literature, it is sufficient to indicate the main directions of the questions concerning moisture-resistant plants. In the textbooks of S. P. Kostycheva, N. A. Maksimova and others, (also foreign workers, for example A. K. Kraft) there is no information on the physiology of plants which are in environments of surplus moisture. Experimental studies pertaining to this theme concern separate aspects of plant life: changes in transpiration, anatomical characteristics [1], development of individual elements of the spike [2], water balance in the leaves of various grains [3], water regimen in leaves [4], etc. Recently, in connection with broad undertaking in the USSR of irrigation measures, the question of the water regimen in agricultural crops has been actively investigated. In studies on this subject there has been investigated in detail the matter of optimum and insuficient water supply of plants, but rarely has there been concern with the question of the effect of excess moisture brought about by irrigation and rainfall [5-8]. In these cases observations of a general order are made, for example, that excessive water supply destroys the relationship between the growth of the above-ground and below-ground plant organs [5]. Also, in recent literature in this country on utilization of turfy, swampy soils with excess moisture, there can be noted manifestations of a general order in plant life; for example, under conditions of surplus moisture, the grain is formed badly and the vegetative period is protracted [9]. Only in the most recent studies [10, 11] has there been investigated the effect of excess moisture on the growth, development, and yield of summer bread grains.

In the above-cited studies, the authors come to the conclusion that at 85% of full moisture capacity of the soil, there are created favorable conditions for plant development. The influence of excess moisture of the soil and the atmosphere is touched on only episodically in the various studies, without disclosing the essential process of the total life activity. At the same time, as indicated at the beginning of this paper, the study of the problem of excess moisture in plants is of very great importance over wide zones of the USSR.

As assigned by the Amur State Selection Station, in investigations conducted in 1933 on the effect of excess moisture on the development and yield of summer wheat, we set up a basic experiment under conditions which approximated those in nature. In the Far East excess moisture brought about by the monsoons coincides with the beginning of threshing of summer wheat. Under the drenching rain, the vigorously developing plants which promise a rich crop are markedly slowed in their development. As a result the ears are undeveloped with poor seed.

To reproduce the natural conditions of wheat development in years of excessive moisture, the main line of the work consisted in transferring plants which were growing vigorously under optimum conditions into vegetation flasks in a light chamber with a heightened content of water vapor in the atmosphere and simultaneous over-watering of the soil in the vessels. The transfer was made at the beginning of the phase of ear-ripening.

The chamber, which was above six feet in height, was ventilated. The dark side of the room was to the south. The plants in the chamber were illuminated by direct sunlight from sunrise to 10 in the morning, and from 5:30 in the evening to sunset. Humidification of the air in the chamber was carried out in the course of the day by multiple sprinklings of the interior portion of the chamber and the material which was of the dimensions of the entire dark wall. The relative moisture in the chamber ranged between 61 and 91%, and averaged 13.1% higher than on the platform. Surplus watering of the soil in the vessels from 70% to 115% of full moisture content was conducted with isotonic solution, so as to clarify the effect of one factor on the plants, the increase in soil moisture. Despite the satisfactory nutrient value of the soil (in quantity of 1 kg per plant), fertilizers were introduced so as to eliminate the influence of any nutrient insufficiency. The basis of our calculation was that the wheat grain contained 3.6-4.0% nitrogen, 2.0% ash and the stalk about 1% nitrogen and 5% ash [12]. The yield per plant was calculated as 2.5 g grain and 5.8 g stalk. Phosphorus and potassium were each introduced in a quantity of $^2/_3$ of the nitrogen. The concentration of the salt solution added was 0.32%. The seeds of two varieties — Liutestsens 62 and Cesium 111 — were planted in the vessels on the 24th of May.

Field trials have shown the resistance of Liutestsens 62 and the lack of resistance of Cesium 111 to surplus moisture. Based on seven years of study in the Amur Selection Station, Liutestsens 62 emerged as the variety with the highest yield by comparison with many other summer wheat varieties. The Cesium 111 variety was of interest because of its high milling and bread baking quality. The similarity in various phases of development of the two varieties was most helpful in comparing results of the studies.

Five plants were cultivated in each vegetative vessel. In all, 405 plants of each variety were used in the study. Of these, 125 plants were transferred to the chamber at the beginning of ripening; the same number were kept on the vegetation platform with an optimum degree of soil moisture — 70% of moisture-holding capacity — as controls.

Later in the study there was investigated the effect only of excess soil moisture on the plants. 75 plants of each variety were grown on vegetation platforms at 115% of full moisture capacity at the beginning of their development. Excess moisturing was carried out with isotonic solution on the 8th day after sowing.

40 plants of each variety were used for tests as to the effect of illumination of plants which were grown under conditions of excess moisture. The same number of plants were used for tests on excess moisture in the soil by a solution which contained salts in three times the previous concentration.

At the start of the study, we assumed that one reason, possibly the most important one, for the poor yield of wheat with excess moisture was inhibition of the root system activity.

The sample was collected from the two most highly developed plant stalks, and the others were removed. The above-ground portion of the plant was removed, except for the lower portion of the stalk, to which was attached a tube for collection of the sap.

The first experiment on daily collection of sap was conducted on July 23 with Liutestsens 62, using three variants: 1) plants cultivated on a vegetation platform with 70% of total moisture capacity of the soil (L. 70); 2) 24 hours before the start of the test, the plants were transferred from soils with 70% humidity to one with 115% humidity (L. 115); 3) plants grown on a vegetation platform with 115% of soil moisture from the beginning of the test (L. 115 pl.).

The quantity of sap collected per day per stalk in cm^3 was as follows:

L. 70	L. 115	L. 115 pl.
(average of 115 stalks)	(average of 15 stalks)	(average of 8 stalks)
0.35	0.01	0.05

The second test was carried out on Liutestsens 62 on July 7. The test variants were: 1) plants grown under normal conditions with 70% soil moisture (L. 70); 2) plants which one day before the start of the test were transferred from vegetation platforms into the chamber, and then subjected to the action of soil and atmospheric overmoisturing (L. 115 c); 3) plants under the same conditions as in the second case, but with a three-fold increase in osmotic pressure of the soil solution (L. 115 3 o.p.).

The quantity of sap per day per stalk in cm^3 was as follows:

L. 70	L. 115	L. 115 3 o.p.
(average of 9 stalks)	(average of 8 stalks)	(average of 8 stalks)
0.267	0.044	0.044

In the third test, carried out on July 10, the variants were the same, but the plants in the chamber were held for 3 days with excess soil moisture, to the extent of 115%.

The quantity of sap per day per stalk in cm^3 was as follows:

L. 70	L. 115	L. 115 3 o.p.
(average of 8 stalks)	(average of 8 stalks)	(average of 7 stalks)
0.400	0.013	0.029

Tests with Cesium 111 showed similar results – a marked decrease of sap exudation with over-moisturing.

Investigation of the condition and development of the root system was conducted 1 month after the start of the study. At this time there was observed a clearly depressed condition of the plants which were grown from the beginning of the test with excess soil moisture on the vegetation platform. The inhibition could be seen as yellowing and dying off of the leaves. In some cases death of the plant occured. The roots of the plant variant L. 115 penetrated to a depth of 7-13 cm, C. 115 pl. 7-15 cm, L. 70 9-16 cm, C. 70 9-16 cm. In the plants grown at 115% of soil moisture, in which there was observed a depressed condition, from the earing node instead of withered, dead roots, there developed new fresh white resilient roots. The latter were completely viable. The pH of endoderm center was 4.4, and that of the bark parenchyma 6.0; all the cells were alive (this was indicating by staining of slices with neutral red). NO_3 and NO_2 ions were found in the roots in large quantity, independent of soil moisture differences. Microchemical reactions failed to reveal the presence of amino acids in the roots at both levels of soil moisture.

Development of plants of both varieties with continual excess moisture lagged behind the development of the control plants to a marked degree; the accumulation of dry substance decreased to $\frac{1}{6}$ - $\frac{1}{8}$, the height of the plant was 0.4 to 0.5 that of the control, the number of stalks per plant diminished to $\frac{1}{2}$, etc. It is of interest that the water content in the plants under excess moisture decreased by 5-15%.

The most resistant Liutestsens 62 plants which yielded germinating seeds stood out. This makes possible a means of obtaining moisture-resistant varieties [13].

Aside from inhibition of the root system activity, a second cause of lack of wheat fruitfulness under conditions of excess moisture was supposedly disturbance of plant substance metabolism, for the manifestation of which we undertook investigation of enzyme activity. The energy of decomposition of hydrogen peroxide by catalase and the activity of complex enzymes which hydrolyze starch to the stage of reducing sugars were determined first with variants grown on over-moistured soils from the beginning of the plant development.

The catalase activity per g dry substance of above-ground portion of the plant, as determined on June 25, was as follows (10-12 plants were used for each variant):

Test variant	L. 70	L. 115	C. 70	C. 115
cc 0.1 N $KMnO_4$	0.0	8.99	0.0	8.10

As indicated by the data, over-moisturing of the soil brought about a significant catalase activity in the above-ground portion of the plant of both varieties. In undergoing a marked lack of oxygen with excess soil moisture, the plants increased their activity of oxidative enzymes in the above-ground portions as well. In the determination of June 26, the total enzyme activity in the above-ground portion of the plant hydrolyzing starch to reducing sugars expressed in mg glucose per g dry substance was as follows (10-12 plants used for each variant):

Test variant	L. 70	L. 115	C. 70	C. 115
mg per g	64.3	29.0	162.2	29.5

A drop in the carbohydrate enzyme activity is caused evidently by disturbance of the plant light supply. While the decrease in enzyme activity in Liutestsens 62 with excess soil moisture (variant L. 115) compared with the control with normal soil moisture (L. 70) was more than double, in Cesium 111 it was 5.5 times. This circumstance is an evident deomonstration of the physicochemical characteristics of the structure of Cesium 111, on which depends the lack of resistance to over-moisturing.

The data obtained confirm that the transpiration in plants with excess soil moisture proceeded less uniformly than in control plants at 70% soil moisture. In Liutestsens 62 this is shown by difference in transpiration of the upper and lower sides of the leaves, and for Cesium 111 in a change in transpiration at various periods. Together with these tests there were conducted studies on the condition of the stoma by fixing epidermis slices in absolute alcohol. The condition of the stoma as regards the openings, changes in most cases in proportion to the magnitude of transpiration.

In returning to the basic test variants, there can first be described from the beginning the observations on the course of growth of plants which were transferred to the excess moisture chamber. After 8-9 days the lower leaves of the plants in the chamber all become yellow. The leaves of the middle layers also partially yellowed and wilted in varying degree, partial curling was frequently observed. Only the leaves of the upper layer had a healthy outward appearance. Each variety formed on, the average, 4 spikes per ear.

The grain in the plants which were in the chamber was sickly the yield was lower by several times than the control plants; the percentage of water in the vegetative mass diminished the first two weeks after transfer of the plants into the chamber and then the water content increased.

Under conditions of excess moisture the grain yield and accumulation of dry matter markedly decreased. The percentage of moisture in the plants at the beginning of the experiment also decreased. Experiments conducted at the same time with 80 plants on the vegetation platform in all cases showed as striking a picture of the effect of sunlight on plants when the soil was excessively moist. Even after 3 days, only the leaves of the upper layer remained green and externally healthy; leaves of the lower and mid regions became yellowed and wilted. The same phenomena may occur under natural conditions. Evidently, the cause of destruction of the major portion of the leaves in this case consists in a specific condition of the leaf tissues and in a disturbance of metabolism in these organs. Changes in the magnitude of transpiration in plants transferred to excessive moisture with full solar illumination cannot be the cause of plant destruction, as shown by the data below, even if disturbance of the processes is considerable.

Fourteen days after the transfer of plants into the chambers in the basic test variant during grain ripening the enzyme activity was studied.

The activity of the enzyme complex which produces starch hydrolysis to the stage of reducing sugars in milligrams of glucose per g dry substance was as follows:

Test variant	L. 70	L. 115 c	C. 70	C. 115 c
Stems	0	0	0	1.22
Spikes	0	0	0	0

The peroxidase activity in the spikes per g dry substance in percent (activity of L. 70 taken as 100) was as follows:

L. 70	L. 115 c	C. 70	C. 115 c
100.00	89.20	17.61	20.55

It is evident from these tests that the plants of the nonresistant variety Cesium 111 react to a lack of oxygen in the soil by increasing the activity of oxidative enzymes in the above-ground organs. We encountered this phenomenon earlier in studying the physiology of plants which are subjected to conditions of excess moisture from the beginning of development.

The relationship of the P_2O_5 in the grain (in grams per spike) and in the stalk (in grams per plants) is referred to in order to represent graphically a basic variant studied – the course of the advent and transfer of phosphates to the plant organs during the periods of ripening and complete ripeness.

$$\frac{\text{L. 70 Grain 20. VII 0.0025}}{\text{L. 70 Stalk 20. VII 0.0227}} = 0.110;\ \text{the same 16. VIII } \frac{0.0137}{0.0125} = 1.096$$

$$\frac{\text{L. 115 c grain 20. VII 0.0008}}{\text{L. 115 c stalk 20. VII 0.0176}} = 0.045;\ \text{ditto 16. VIII } \frac{0.0022}{0.0325} = 0.068$$

$$\frac{\text{C. 70 grain 25. VII 0.0023}}{\text{C. 70 stalk 25. VII 0.0249}} = 0.092;\ \text{ditto 18. VIII } \frac{0.0093}{0.0007} = 13.286$$

$$\frac{\text{C. 115 c grain 25. VII 0.0009}}{\text{C. 115 c stalk 25. VII 0.0254}} = 0.035;\ \text{ditto 18. VIII } \frac{0.0023}{0.0187} = 0.123$$

If the relationship of the coefficients of full ripeness: to the grain ripening, are then calculated by periods, the figures obtained will demonstrate the magnitude of the lag in phosphate transfer to the grain from the vegetative mass when the moisture is excessive by comparison with normal cultivation; this is seen from the following data:

$$\text{L. 70 } \frac{1.096}{0.110} = 9.96;\quad \text{L. 115 c } \frac{0.068}{0.045} = 1.51$$

$$\text{C. 70 } \frac{13.286}{0.092} = 144.41;\quad \text{C 115 c } \frac{0.128}{0.035} = 3.51$$

As can be seen, the movement of P_2O_5 from the vegetative mass into the grain for Liutestsens 62 is retarded approximately to one-sixth, and for Cesium 111 to $^1/_{41}$. The excess quantity of phosphates in Cesium 111 in the chamber enriches the vegetative mass. The extremely marked disturbance of metabolism in Cesium 111 in the case of phosphates, the most important substances in wheat nutrition, is indicative of the variety's lack of moisture resistance.

TABLE

Transpiration (per sec.) of Liutestsens 62 Variety Wheat Plants

Weather conditions and test variant	Illumination from below	Opening of stoma, in ocular micrometer divisions	Upper side, opposite the one illuminated	Opening of stoma, in ocular micrometer divisions
Cool, cloudy				
L. 70	52; 60	0.3	52; 35	0.7
L. 115 pl.	65; 47	0.1	48; 37	0.8
L. 115 pl. 3 o.p.	110; 82	0.15	49; 48	0.6
Hot, sunny				
L. 70	105; 65	0.15	46; 44	0.3
L. 115 pl.	140; 120	Few 0.1	55; 60	0.1
L. 115 pl.	0.0; 140	Almost all	175; 75	0.1

In addition to the experiments described above, others were conducted with a threefold increase in the osmotic concentration of soil solution, which demonstrated very poor plant development under these conditions and a very considerable decline of yield and a marked disturbance of phosphate metabolism.

In concluding the study, the anatomical characteristics differentiating plants subjected to excessive moisture from normal ones should be stated.

Despite the large difference in development between dwarf plants on soil with a constant excess of moisture and those developing vigorously under normal conditions, the same number of dimensions of stoma are noted per unit of mid-tier leaf area on both sides of the leaf. This is worthy of attention, since the degree of differentiation

is quite considerable as judged by other quantitative anatomical features.

In plant leaves which are maintained at a constant 115% soil humidity from the beginning, the differentiation of palisade and spongy parenchyma is almost absent. The cells of the upper and lower side of the leaf area are of the same size, rounded, and have a strongly thickened sheath, and do not differ in size in any part of the leaf.

With constant excess soil humidity the stalk structure differs very markedly from the structure under normal soil moisture because of the small cell size and the presence of very large amounts of intercellular tissue which creates a very considerable tissue porosity.

An excessive moisture in the soil and atmosphere brings about the following changes in the structure of anatomical elements in vigorously developed plants 12 days after transfer to chambers. There is a change in the nuclei in the majority of subsidiary cells which close their stoma. This was established for the green, externally completely healthy leaves of the upper tier. The nuclear deformation consists of strong lengthwise stretching of the subsidiary cell, so that at times the stretched nucleus occupies the same length in the inner part of the cell as the cell itself. At times, instead of the nucleus, an accumulation of its splintered portions is noted in the subsidiary cell. The configuration of subsidiary cells is often change: the walls aquire an irregular delineation. In the closing cells and in all other leaf cells there are no similar manifestations of nuclear destruction and change in walls. These observations were conducted on undamaged epidermis, and underlying tissue.

Apparently, some elements, originally mechanical, undergo a chemical change in plants in a moist chamber, since they do not disclose typical staining, characteristic of plants under normal conditions. The mechanical elements of Liutestsens 62 plants are stained not yellow, but a lusterless brown-yellow color by chlor-zinc-iodine.

SUMMARY

1. One of the main resons of crop failure of Liutestsens 62 and Cesium 111 under conditions of surplus moisture is the functional disturbance of the root system which is manifested in a sharp decrease in sap excretion. Excessive moisture disturbs aeration of the soil and consequently adversely effect the development of the active part of the root system.

2. Plants of these two varieties of summer wheat exposed to surplus moisture (115% of the full moisture-holding capacity of the soil) developed poorly after earing. Accumulation of dry substances in these plants falls sharply, the amount of water in tissues decreases, transpiration is irregular, catalase activity increases greatly. If the soil is deficient in oxygen, the latter is utilized from the aerial parts of the plant. Enzyme activity which results in hydrolysis of starch to the level of reducing sugars abruptly decreases, especially in Cesium 111 – which is a nonwater-resistant variety. Excessive soil moisture causes differenciation of varieties. As a result, some plants of Liutestsens 62 form ripe and germinating seeds. This makes selection possible and allows one to select a more water resistant variety.

3. Accumulation of dry substance and crop yield of plants were significantly reduced if the plants were exposed to surplus moisture conditions in the atmosphere and soil at the beginning of earing. Under these conditions both varieties differentiate. Differentiation of Cesium 111, the nonwater-resistant variety is especially great; this is manifested in the condition of the plants, in the activity of carbohydrate enzymes which varies from plant to plant. An increase in the activity of oxidative enzymes in Cesium 111 is observed and there is a pronounced disturbance in phosphorous metabolism. Changes in the physiological processes of Liutestsens 62, the water-resistant variety, are less.

A three fold increase of the osmotic concentration of the soil solution causes a sharp decrease of the crop yield and abrupt disturbance of phosphorus metabolism.

Surplus moisture in sunlight causes the death of most of the leaves of the plants at the earing phase. The anatomical structure of plants also undergoes changes. In the extreme case – presence of surplus moisture from the beginning of the development of the plant – the anatomical structure acquires features of swamp plants.

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CHARACTERISTICS OF DORMANCY AND NUCLEIC ACID METABOLISM IN SOME FLOWER CULTURES

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Many investigators have studied plant dormancy. Studies instituted in 1851 by Zheleznov [1] were further developed in the studies of Muller-Thurgau [2], Iost [3], Iohannsen [4], Petetolchin [5], Pfeffer [6], Molisch [7], Bordage [8], Appleman [9], and Coville [10], and beginning with 1926, in a series of studies where considerable attention was given to metabolic problems, of which the studies particularly worth mentioning are those of Denny [11, 12], Thornton [13, 14], Guthry [15], Hemberg [16, 17], Croker [18], Berton [19], Zeding [20], Genkel', et. al. [21-30].

As a consequence of these interesting studies, definite directions were evolved in investigations, and many different points of view were expressed on the problems of the significance of the main factors in the onset of dormancy in plants and their organs, and their emergence from dormancy. The main directions were as follows: a number of investigators assigned major significance to gaseous exchange in the tissues. Some emphasize the significance of heightened intensity of oxidative processes when the plant emerge from the dormant state; others the significance of temperoary anaerobiasis, which decrease the O_2 content in the tissues and increase the CO_2 concentration. Some authors ascribe a special role to sulfhydril compounds and, particularly, to glutathione, others emphasize the role of inhibitors, which slow the growth and the role of auxins, others again consider that dormancy is conditioned by a deficiency of soluble nutrient compounds in tissues. And finally, a number of investigators ascribe special significance to the condition of the plasma in dormant plants and upon their emergence from dormancy. Most of these views are based on accumulated data and are of great interest, but they are not devoid of contradictions. Our opinions as to statements in recent literature on plant dormancy are given below.

Thornton [14] considers the characteristic indication of dormancy to be the absence of bud growth, non-germination of seeds, bulbs, tubers even under favorable conditions. Plants and seeds need the activity of low temperatures to emerge from dormancy. Thornton gives great significance to gaseous exchange in tissues upon emergence from dormancy. He points out that potato tubers emerge from dormancy when the oxygen content in tissues is lowered to 5-10%, but that when its content was increased to 20% the tuber dormancy was prolonged. Just the opposite is observed in lily bulbs, which emerge from dormancy upon increase of oxygen content, while upon increase of CO_2 their dormancy is prolonged.

Lange [31], analyzing the dormant state in plants, emphasizes the role of external factors: temperature, change in photoperiods, as well as the significance of the internal mechanism determining dormancy due to the presence of inhibitors, which slow the growth and the effect of individual enzymes.

Doorenbos [32] also calls attention to the role of external and internal factors on the advent of plant dormancy. Of the external factors he singles out deficiency of water and low temperatures as affecting the advent of plant dormancy. As internal factors determining dormancy, he considers differences in tissue conditions. Thus, in summer dormancy, in his opinion, the tissues are not in a state of deep dormancy, and the absence of growth depends on correlative interrelations in plants. Winter dormancy is based on the deep dormancy of all tissues.

Zeding [20] attempts to clarify whether the condition of plant dormancy is due to the low auxin content or whether it is due to a high inhibitor content. He concludes that the period of bud dormancy in woody plants and

potatoes is regulated by substances inhibiting growth. Under certain conditions the inhibitors are destroyed and germination begins. Growth-producing substances, entering from plant reserves, or newly synthesized, fortify the growth but do not determine dormancy since attempts to utilize similar chemical preparations for early forced growth proved unsuccessful. At the same time, when dormancy was disturbed by chemical and physical means, the content of growth-producing substances in buds was increased. In the majority of seeds, dormancy is also conditioned by a high inhibitor content.

Leopold [33] expressed a number of considerations on the problem of the physiological basis for plant dormancy. He focuses attention on biochemical processes occurring at the zone which surrounds meristematic tissues. In the dormant state the seeds, ligneous buds and potato tubers contain acid inhibitors. They block the sulfhydril groups of some enzymes, particularly that of amylase and thus inactivate them. Glutathione and other compounds containing the sulfhydril group suppress the inhibitors and activate sulfhydril enzymes important to growth. Leopold considers that even though opinions exist as to the primary role inhibitors exert during the period of plant dormancy, nonetheless the so-called growth-producing substances play no lesser role.

Individual authors (Doorenbos, Leopold), as was indicated, emphasize the significance of processes occurring in plant tissues during the dormant period. But these were only passing remarks, unsupported by experimental data of the authors themselves.

Only in the studies of Genkel' and collaborators [21-30] was it shown by vast experimental data that in dormant plants a number of characteristic features were observed in the condition of biocolloids in the plasma of cells and tissues. In plants and their organs (buds, tubers, seeds) in dormant periods the protoplasm differs by a diminished capacity for swelling, is kept away from cell walls, is covered by lipoids on the surface; simultaneously the plasma penetrability is diminished and viscosity increased. A decreased metabolism in cells, tissues and organs depends upon the physicochemical condition of the protoplasm.

The activity of oxidative [25] and other enzymes is considerably diminished, the respiration intensity lowered. Visible processes of growth are absent. The ability of plants and their organs to pass over the dormant state constitutes a biologically useful property, acquired in the evolutionary process, helping in resisting unfavorable conditions, since it is precisely during the dormant period, when no growth occurs, that the plants are most resistant to high and low temperatures, to water deficiency and other external influences.

All these observations and deductions are based on much experimental work. Investigations were conducted on buds of woody, fruit, bushy cultures, on seeds, on potato tubers. To account for lack of such investigations on flower cultures, we conducted a study of some bulb and rootstock flower cultures in a dormant state and at the time of emergence from dormancy. The investigation was conducted with bulbs – tulip, narcissus, lily, tuberous-bulby plants – gladioli, and on rootstock plants – iris.

The study was conducted on cell protoplasm, on plasma separation and on lipoid reaction and nucleic acids. Investigations were conducted by cytochemical and biochemical methods. Nucleic acids in tulips and narcissi were determined biochemically.

Just as dormancy is characterized by a number of symptoms in the condition of plasma biocolloids and lowering of metabolism, growth is characterized by a vigorous rise in life activity. During the dormant period processes take place in preparation for an outburst of life activity. Sabinin [34-36] expressed opinions on the significance of accumulating nucleic acid at a "secret period of growth" (as he calls dormancy), determining vigorous growth subsequently. He considered growth as a new formation of protoplasmic structures, closely related to protein synthesis. Protein synthesis depends on the presence of nucleic acids, as originally shown in 1941 by Caspersson [37]. From this the significance which Sabinin ascribes to nucleic acids for formation of new structures and the development of growth processes is understandable. By direct experimentation, conducted in 1948 by Polozova [36], it was shown that by added feeding with purine and pyrimidine bases, which are nucleic acid components, the growth of oat coleoptiles was increased.

The remarkable studies of Brachet [38] showed that cell basophilia are dependent on high nucelic acid content and are closely related to the capacity for intense growth of embryos. In one of the most recent studies, Brachet [39], by dipping the ends of onion root into a solution of crystalline ribonuclease, studied the entry of labeled amino acids into proteins and labeled adenine into DNA. These experiments demonstrated a direct relationship of ribonucleic acid (RNA) with protein synthesis and desoxyribonucleic acid (DNA), since when it was decomposed

by ribonuclease, the processes of inclusion of labeled amino acids into proteins, and labeled adenine into DNA, ceased.

Belozerskii [40, 41] points out that an accumulation of nucleic acids precedes intense growth. Thus, when old microbial cells with a low RNA content, which ceased to grow, are placed in favorable nutritive conditions, they begin to form RNA and the cells begin dividing. The phase of accumulation of nuclear substance precedes cell division. Differentiated cells do not contain RNA, but in meristematic, intensely dividing cells and in elongation stages, the RNA content is high. DNA participates in the determination of form. At present, DNA is also considered a factor in stabilization of specific proteins, in relation to transmitting hereditary properties.

Konarev [42-44] has shown that accumulation of nucleic acids is related to conditions of nourishment, and that there is less accumulation when the plant is hungry and the growth is inhibited. In studying nucleic acid and protein content by zones of root growth of sunflower and kidney beans, he showed that their content is greatest in the zone of active growth (meristematic) and gradually declines from the root apex toward its base. He also showed the relation between RNA content and cell differentiation, particularly when capsules and envelopes are formed. Höhn [45] showed that the growth of watercress was inhibited when nucleic acids were blocked and inactivated by thiouracil.

This brief review of some studies on the role of nucleic acids shows how significant that role is in accomplishing growth processes. These considerations constituted the basis of investigation of nucleic metabolism of bulbous plants in dormancy and their emergence from it.

Observations on the condition of the nucleus in dormant tissues were conducted by Genkel' [46] with the use of a phase-contrast microscope; in expanding the study in this research Satarova [24] observed a stronger Feulgen reaction of DNA in the potato eye zone when potatoes emerged from dormancy. Oknina and Barskaia [23] showed that during the dormancy period multinuclei are observed in seed cells and in the growth and flower buds in woody cultures, and a nuclear substance is accumulated which provides a vigorous growth of tissues upon emergence from dormancy. Petrovskaia [27-28] presents data as to accumulation of DNA and RNA in flower buds upon emergence from dormancy and on the change in DNA content in orchids in relation to the formation of generative organs. Camefort [47], using the Brachet method, showed that gymnospermous Taxus baccata and Picea exelsa contain the highest amount of RNA in buds during active growth, but in the period of winter dormancy some tissues are extremely poor in RNA.

All these data confirmed the significance of nucleic acid accumulation for development of growth processes at emergence from dormancy, which also induced us to give attention to this problem.

METHODS

The scales of bulbous plants, tulip and narcissus, the embryonal leaves, parts of flowers, as well as points of growth and pieces of rootstock tissue of iris and pieces of tuberous bulbs of gladiolus, were fixed by the Helly method (for RNA) and by the Zenker method (for DNA), or in steam of a 2% osmium solution (for lipoids). After paraffining, the materials were cut on a slide microtome. Tests for RNA were made by staining with methyl green pyranin by comparison with preparations treated with ribonuclease.

Tests for DNA were made by the Feulgen method with Schiff reagent. The study of the reserve content of nutrient substances was conducted on slices of living matter; fats and lipoids were stained by sudan P and scarlet; sugars were determined by reaction with α-naphthol, starch by reaction with Lugol solution, proteins by the xanthoproteic reaction.

Biochemical determination of nucleic acid phosphorus was conducted by the Schmidt-Tannhauser method modified by Abelev [48], phosphorus was determined by the Fiske-Subarrow method [48].

RESULTS

The investigations conducted showed that bulbous and other flower cultures investigated in a state of dormancy and characterized by a number of features, common to a majority of plants in the dormant period – and at the same time by some specific features. In Figure 1 a, b it can be seen that the points of growth in narcissus and iris in the dormant state have a positive reaction for lipoids when stained by osmium. When greatly enlarged, (Figure 1 c, d), a separation of plasma and a positive lipoid reaction is seen in the cells of the main growth points.

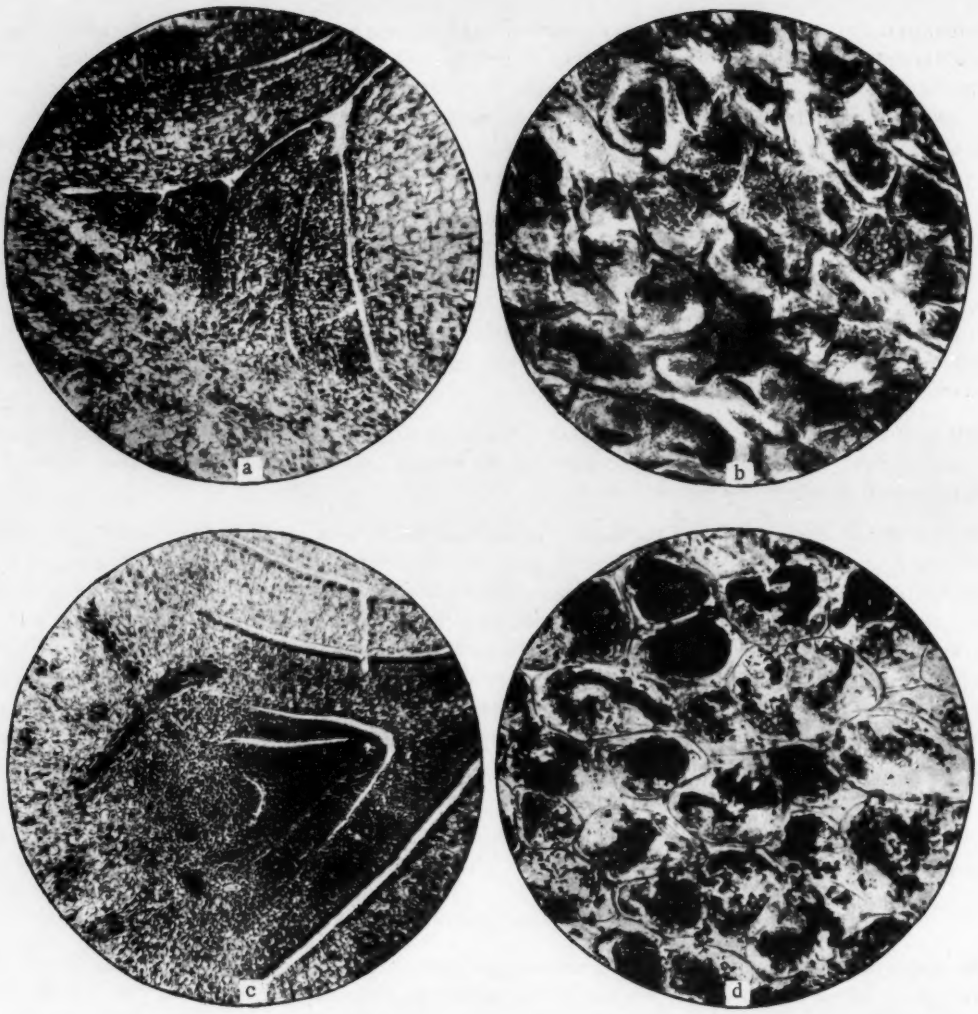


Fig. 1. Point of growth in dormancy. a) Narcissus; b) iris; lipoid test with osmium (enlarged 63 times); the same in individual cells: c) narcissus; d) iris (enlarged 240 times).

In gladioli bulbs in a dormant state, a marked separation of plasma from cell walls (Fig. 2) is observed.

A positive lipoid reaction is observed in the lateral dormant tulip buds (Fig. 3). During September the DNA reaction at the dormant point of growth of tiger lily (the first year's bulb is grown from seed) is rather weak (Fig. 4 a). When the lily emerges from dormancy, the DNA reaction in sprouts is considerably more intense (Fig. 4 b) than at the dormant point of growth. In bulbs such as narcissi and tulips, simultaneously with incipient points of growth in the state of deep dormancy, there are well-formed sprouts in the bulb with differentiated reproductive organs since autumn, which are characterized by a high nucleic acid content and not as deep a dormancy, since mitoses are observed in individual tissues in late autumn.

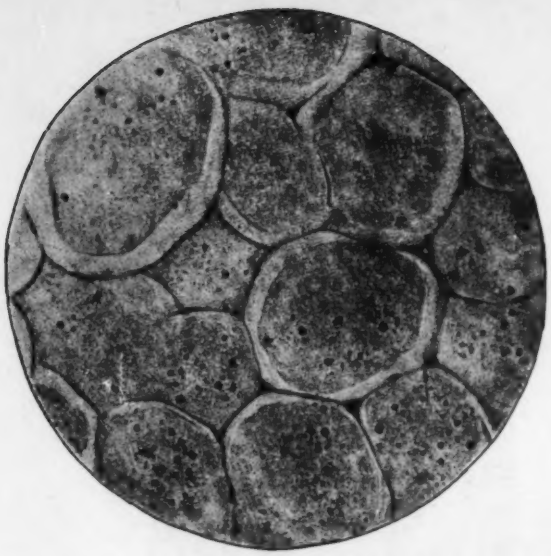


Fig. 2. Cells of tuberous bulbs of gladiolus in dormancy.

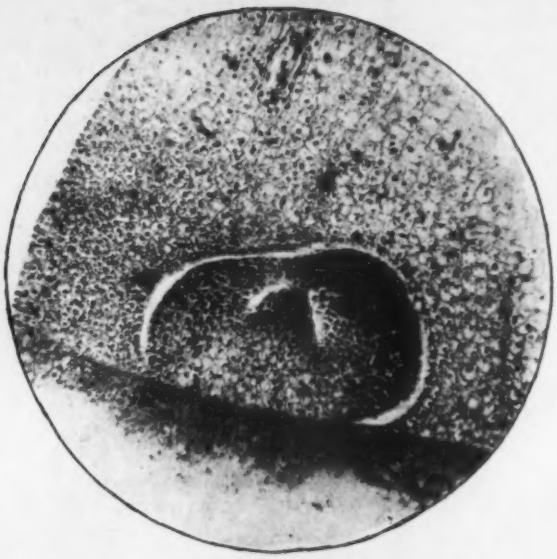


Fig. 3. Dormant lateral tulip bud (lipoid test with osmium).

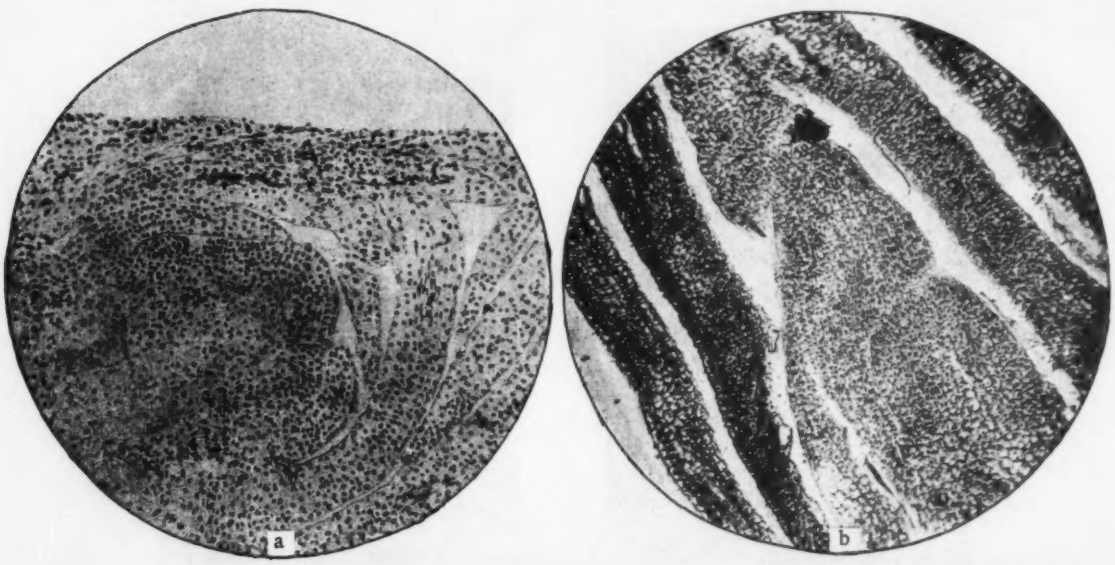
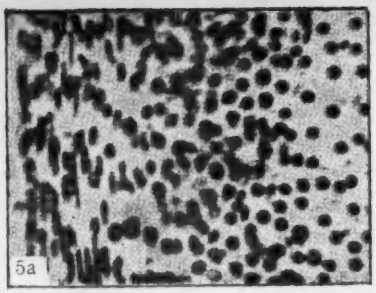
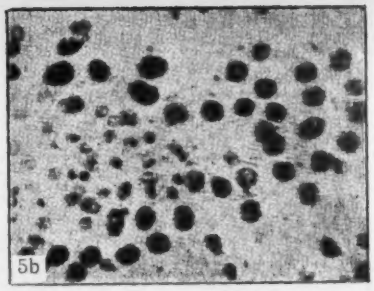


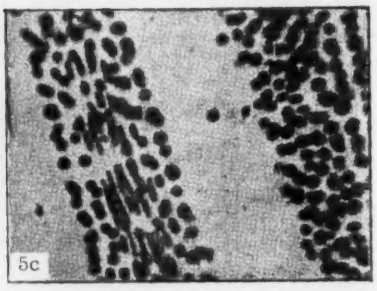
Fig. 4. Point of growth of tiger lily in dormancy a (September 25, 1956) and as emerged from dormancy b (May 18, 1957).

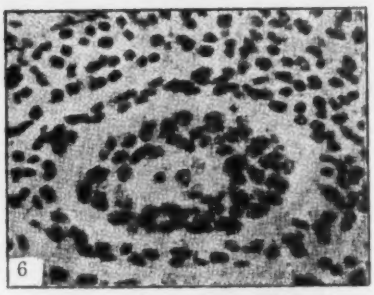
In Fig. 5, well-formed parts of the flower can be seen in the central bulb sprout of Golden Harvest tulip. Tissues of pistil (5 a), anthers (5 b) and bud leaves (5 c) produce an intense DNA reaction. In the pistil cells (5 a), mitoses are observed. In bulbs of the narcissus variety Mrs. Percy Nye (from Adler), there were sprouts since autumn which were well-formed with flower organs, in which a differentiation of ovules and pollen continued during autumn.

In Fig. 6 can be seen parts of the ovary with the seedbud, in which an intense DNA reaction is observed. In the organs of the tulip flower an intense RNA reaction is also observed (Figs. 7 a and b).









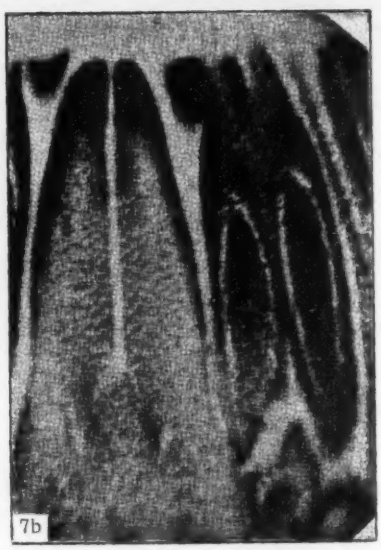


Fig. 5. Tulip flower (reaction to DNA) : a) in pistil; b) in anther; c) in embryonic leaves (enlarged 360 times).

Fig. 6. Reaction to DNA in narcissus seedbud (enlarged 360 times).

Fig. 7. Reaction to RNA in tulip flower (stained with methyl green pyronin): a) treated by ribonuclease; b) untreated (enlarged 72 times).

• This plate is reproduced from a color plate, thus some detail has been lost.– Publisher.

TABLE 1

Nucleic Acid Content of Various Tulip Tissues (phosphorus in mg per g dry basis)

Organ	Nucleic acids	Comprising:	
		RNA	DNA
Variety Mothers Day (dormancy) November 12, 1956			
Bulb scales	0.325	0.173	0.152
Embryonic leaves	3.434	1.654	1.780
Variety Mothers Day (dormancy) February 14, 1957			
Bulb scales	0.115	0.047	0.068
Embryonic leaves	1.974	1.118	0.856
Flowers	2.765	0.444	2.321
Variety Golden Harvest (emergence from dormancy April 24, 1957)			
Bulb scales	0.168	0.112	0.056
Embryonic leaves	3.067	1.622	1.445
Pistils	4.984	1.862	3.122
Anthers	2.50	1.215	1.285

The adduced data show that growth points of flower cultures in dormancy differ in a number of features characteristic of plants in a dormant state. In the cells of growth points and surrounding tissues in dormancy in flowering cultures, a separation of plasma is observed, a positive lipoid reaction and a compratively weak reaction to DNA. The central growth points in bulbs (tulips and narcissi of the second and third years of life) are normally well formed by autumn, and have foundations of generative organs by autumn. They are distinguished by a high nucleic acid content (related to formative processes taking place in them), which insures a vigorous development of growth processes, as well as development when they emerge from dormancy. Microscopic observations of nucleic acid reactions in tulip and narcissus are confirmed by data of biochemical analysis (Table 1).

From Table 1 it can be seen that in tulips, variety Mothers Day (from Adler), the total content of nucleic acids, as well as that of DNA and RNA in bulb scales in the autumn is $\frac{1}{10}$ that in the embryonic leaves. In February, ,the nucleic acid content in bulb scales was $\frac{1}{18}$ - $\frac{1}{20}$ that of the embryonic leaves, and $\frac{1}{25}$ that of the reproductive organs. In the tulip variety Golden Harvest, at its emergence from dormancy, the total nucleic acid content in bulb scales is $\frac{1}{10}$ - $\frac{1}{20}$ that of small leaves and generative organs; especially large is the difference in DNA content.

Thus, the data of biochemical investigations fully confirmed the data of microscopic investigations, that DNA and RNA concentrate in meristematic tissues and subsequently in vegetative and generative organs, and their accumulation precedes the rise of life activity – a vigorous growth and development. The high nucleic acid content also, possibly, indicates resistance to low temperatures at the emergence from dormancy in the early spring period, which is characteristic of many species of bulbs, in which the initial small leaves break through snow or appear immediately after the snow melts, when night frosts still occur.

Variations in nucleic acid content and their accumulation in individual tissues in the dormant period is evidently related to the capacity of RNA to accumulate labile metaphosphates [41], which subsequently become phosphorus sources in newly formed nucleic acids.

In bulb scales the nucleic acid content is so insignificant that it can hardly become a source of these compounds for meristematic tissues and generative organs. At the same time, they undoubtedly conserve the reserve

nutrient substances and become basic sources of nutrition for sprouts until their transition to autotropic nutrition. The data on reserve nutrient substances of some flower cultures in the dormant period and while sprouting are presented in Table 2. The data were obtained with the aid of microscopic observations: tests for starch were made with Lugol reagent, for fats with sudan and scarlet, for sugars with α-naphthol.

TABLE 2

Reserve Nutrient Substances of Flower Cultures During Dormancy Period and at Emergence From Dormancy

Plant, organ, condition	Data	Starch	Fats	Sugars
Tulip bulb scales (emergence from dormancy)	23. IV	Parenchyma: ++++ Bark parenchyma: none	Parenchyma: none Bark parenchyma: Finely divided drops	Parenchyma: none Bark parenchyma: ++++
Tulip bulb scales (dormant)	3. VIII	++++	Drops of fat in abundance	–
Narcissus bulb scales (emergence from dormancy)	23. IV	Parenchyma: ++++	Parenchyma: Traces	In all tissues ++++
Narcissus bulb scales (dormant)	3. VIII	++++	++++	–
Gladiolus – tuberous bulb (forced dormancy)		+++	Reaction postive in eye tissues and in the bark parenchyma of tuberous bulbs	–

From the data of Table 2 it is apparent that in a state of dormancy the reserve nutrient compounds are located in bulbs and tuberous bulbs in the form of complex insoluble compounds such as starch and fats, while upon emergence from dormancy a disintegration is noted and a disappearance of fats in individual tissues and a partial decomposition of starch takes place with formation of sugars.

SUMMARY

1. The same fundamental phenomena which were observed in previously studied buds of tree plants and potatoes and also in seeds are also characteristic of flower plants in the dormant state.

2. Separation of the protoplasm and an intense reaction indicating the presence of lipoids are observed in the cells of growing points and in the surrounding parenchyma tissues when these latter are in a dormant state. Storage nutrients in scales of onion plants exist in the form of complex polymer substances. Due to separation of the protoplasm and accumulation of lipoids and of other high polymer compounds onion plants are resistant to low temperatures.

3. The generative organs in such ornametal bulbous plants as tulips and narcissi are formed already in the fall. Differentiation of the seedbud and formation of pollen continued during the late fall and winter (warm 1956-1957 winter).

4. The largest amounts of the nuclei acids, desoxyribonucleic and ribonucleic acids, were detected in the growing points at termination of the dormant state and in embryo leaves and generative organs. This confirms the exceptional role of these acids in growth processes and their importance in the formation of reproductive organs.

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COLD RESISTANCE OF PLANTS AND SOIL PATHOGENICITY

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In the study of resistance of plants to unfavorable enivronmental conditions, the condition of the root system has received an undeservedly small amount of attention. With an abundance of tender growing tips, it cannot undergo exposure to such conditions as drought, salinity, excessively high water levels, low temperatures, etc., without injury. Considering the important role of the roots in the total economy of the plant, aside from their respiratory activity [1, 2], the physiologist is not justified in concentrating his attention solely on the resistance of the aerial organs. Moreover, the influence of unfavorable factors on the composition of the soil microflora, in particular the rhizosphere, especially in combination with their known influence on root excretory activity, may not be ignored. The alteration in the composition and metabolism of the microflora, together with the disrupted metabolism of affected plants, may lead to the development of pathogenic activity in the soil.

It is appropriate to take all this into account in the study of the behavior of thermophyllic plants in low negative temperatures, which do not bring about a cessation of biological activity in the soil but only modify it. In the majority of studies of cold resistance physiologists have limited themselves to an analysis of the aerial organs of plants grown on ordinary soil and chilled to the point of manifestation of external signs of injury – wilting. Usually the factor of pathogenicity of cold soils was not taken into account. Only a few investigators considered the fact that in a number of cases one of the results of chilling thermophillic plants native to the south is injury to the root system, which increases the harmful effect on the aerial organs. Sellschop and Salmon [3] observed root injury in Arachis, cowpea, and corn with chilling to 0.5 – 5.0°, and similar observations were made by Harper [4], who worked with a number of varieties of corn, and Shapkina [5], who worked with cotton seedlings.

The necessity for taking into account the pathogenicity of cold soils is strikingly demonstrated in vegetable culture where, in the spring, there appear lengthy cold periods or even a regular decrease of the night temperatures of the ground below the normal level, there is extensive root injury to thermophillic plants, especially when the moisture level is high [6, 7].

In a previous communication [8] preliminary data were presented which led us to surmise that the factor of pathogenicity of cold soils is of great importance in the resistance of heat loving plants to cold. The experiments described below, carried out in 1957, are devoted to a more detailed explanation of the significance of this factor in the cold resistance of a number of vegetables, melons, and cartain other plants during the early stages of their growth.

METHODS

Plants were grown in frames containing 10 kg of soil taken from the arable layer, supplemented with $\frac{1}{3}$ compost (ordinary soil). Some of the boxes with soil were sterilized in the autoclave at 2 atm. for 40 minutes (sterile soil), while some were sterilized by the cold method in which a 50% dust of tetramethyl-thiuram disulfide (TMTD) or mercuran (2% ethyl mercuric chloride, 16% of the isomer GBH) was added to the soil (0.5 g per kg and 0.25 g per kg respectively) (treated soil). Part of the seeds grown on ordinary soil were treated before sowing with a dust of mercuran (1 g per kg) or TMTD (4 g per kg) – "treated seeds." Each box was sown with 90 seeds, occasionally with 50 seeds, and was watered with Hellriegel's solution at double strength. The second application of this nutrient solution was made after 15 days. The soil moisture level was kept at 70-80% of the saturation

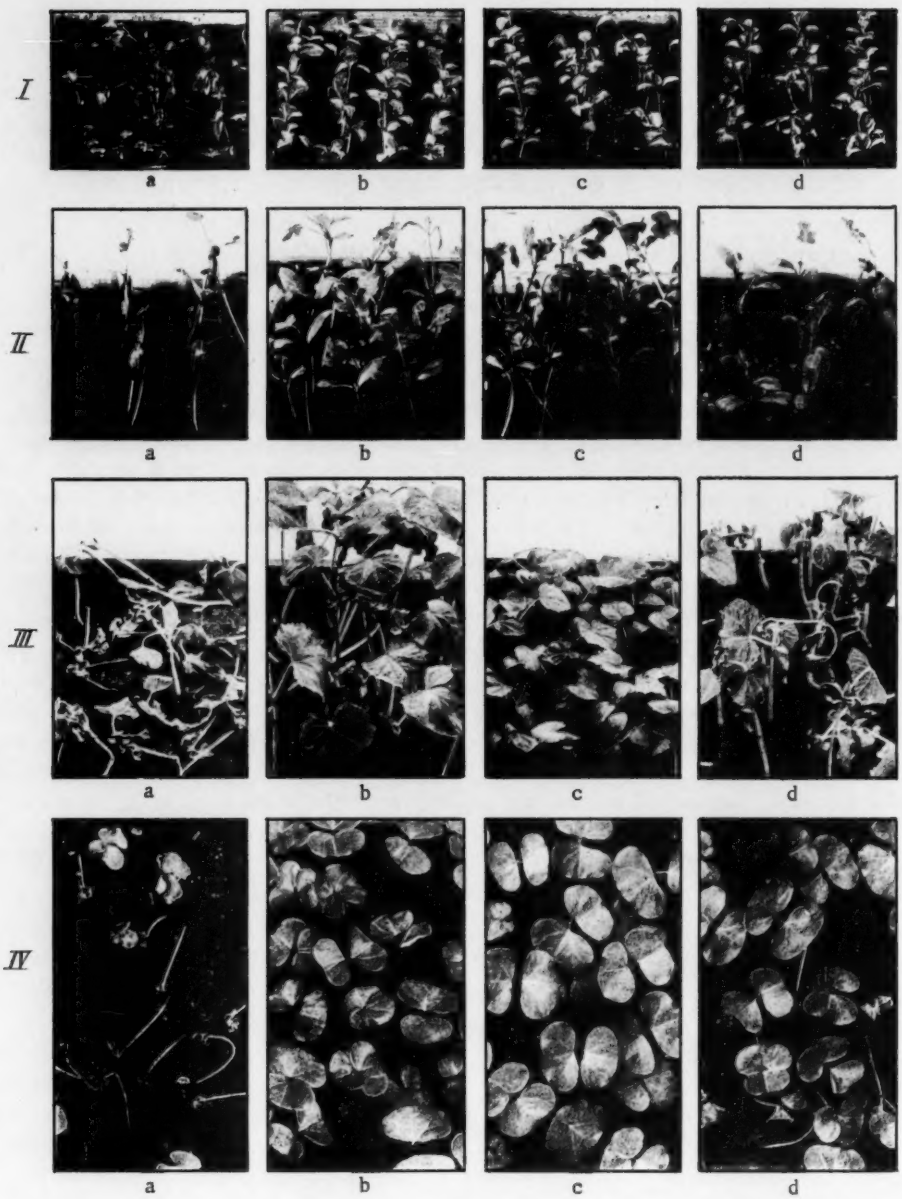

Fig. 1. Influence of chilling on plants grown on ordinary (a), sterile (b) and treated (c) soil and from seeds treated with a fungicide (d).
I) Delikatess eggplant; II) Liubimets watermelon of the Piatigorsk farm; III) Viaznikov cucumber; IV) Egyptian 5904 cotton.

level. Plants were grown in the greenhouse at 25° during the day and 15-18° at night; air humidity varied from 80 to 90%. Plants were usually chilled at the first leaf stage, less often at the second leaf stage; in the spring chilling was carried out in the greenhouse under natural illumination, and at warmer periods it was carried out in cold chambers at the Artificial Climate Station under weak artifical illumination (3-4 thousand lux) at a humidity of 80%. The temperature was gradually lowered after preparation of the plants, and at the end of the chilling period it was slowly riased. After assessment of the cold injury, the boxes with the plants were transferred to a warm, light greenhouse (20-25°), and after three days the number of plants which had diedwere again counted. Plants were chilled in the light or the dark according to the technical means available. Experiments with watermelon and muskmelon were performed under natural illumination; with pepper, Viaznikov cucumbers, cotton and corn artificial illumination was used; eggplant was chilled in the dark. Nerosim cucumbers were chilled four days in the dark, and two days before this and two days after – in a light cold greenhouse.

EXPERIMENTAL

For the elucidation of the significance of soil pathogenicity as a factor in the cold resistance of thermophillic plants we attempted to obtain as many kinds of plants for experimentation as possible.

Of vegetables, eggplant, pepper and cucumbers were used; they were grown on ordinary, sterile and treated soils, from untreated seeds, and also from seeds treated prior to sowing with a fungicide, in which case only ordinary soil was used.

The results of a count of plants lost by chilling under the various conditions are presented in Table 1, and the condition of selected lots is shown in Fig. 1, I and III. The data on the experiment with Nerosim cucumbers are somwhat atypical and we will consider them later. The data on the remaining experiments show that in the chilling period there is a 28 to 45% loss of plants on ordinary soil, while on sterile soil, i.e. under conditions in

TABLE 1

Role of Soil Pathogenicity in Cold Resistance of Certain Vegetable Plants

Plant variety	Lenght of chilling period, in days	Expt. condition	Plant loss in % on the given soil			
			ordinary	sterile	treated with a fungicide	seed treated
Donsky eggplant	2c.10—15° 3c.7 8°	C	28,0	0	1,2	8,6
	1c.12–17°	W	49,5	0	4,7	10,7
		C	44,7	0	3,1	5,2
Delikatess eggplant	Same	W	80,8	1,0	8,2	19,6
		C	38,0	1,0	5,4	21,7
Bulgarian pepper	10c.8–9°	W	99,1	41,5	64,6	99,2
Viaznikov cucumber	2c.14—16° 3c.10–12°	C	41,7	0	0	0
	2c.8–10°	W	90,0	0	0	0
		C	81,8	8,3	8,3	61,1
Nerosim cucumber	2c.9–15° 4c.6—7° 2c.11—15°	W	100,0	60,4	58,3	91,5

Note: C) during chilling; W) after three days at 20-25°. In the experiment with pepper and Viaznikov cucumbers TMTD was used, and in the others, mercuran.

which participation of microflora is excluded, there is no loss or it is not greater than 1%. With sterilization of soil by fungicides, the number of cases in which there is no loss is fewer, but as a rule the loss is not large, not exceeding 5%, i.e. it is significantly less than on ordinary soil. Pre-sowing treatment of seeds with the fungicide is less effective than treatment of the soil, as would be expected, since only a small zone of soil surrounding the seed is sterilized and the greater portion of the root system is outside the sphere of influence of the fungicide.

But even in this case the loss during chilling was not greater than 22%, i.e., 16-40% less than without treatment. The lots described above differed not only in percentage of loss, but also in the degree of injury of the plants which survived. Thus, in the experiment with eggplant Delikatess on nonsterile soil, the leaves and cotyledons of all the survivors (53%) were withered, while on sterile and treated soil – only 12-18% were in this condition; the remainder were without external signs of injury.

In the experiment with Viaznikov cucumbers, 51.6% of the plants which had survived a chilling period on nonsterile soil (58.3%) had wilted cotyledons and leaves, and where the seeds had received a pre-sowing treatment, 85% of the survivors were in this condition; on sterile soil and treated soil, however, only 1.3-4.7% were in in this condition, the remainder being turgescent without external signs of injury. In the experiment with pepper, 11% of the plants chilled on nonsterile soil were uninjured, while with seed treatment there were 29%, with treated soil, 56%, and with sterile soil, 80%.

TABLE 2

The Role of Soil Pathogenicity in Cold Resistance of Certain Melon Crops

Plant variety	Experimental condition	Plant loss, in % on the given soil:			
		ordinary	sterile	treated with a fungicide	seeds treated
Liubimets watermelon of the Piatigorsk farm	C	45.0	0	16.7	18.5
	W	45.0	0	16.7	22.2
Kolkhoznitsa muskmelon	C	50.0	0	0	0
	W	54.0	0	0	0
Gribov summer squash	C	23.1	14.3	0	10.9
	W	78.5	21.4	14.2	34.4

Note: C) during chilling; W) after three days at 20-25°. Summer squash was treated with TMTD, the other varieties with mercuran.

Let us consider the experiment with Nerosim cucumbers. It differs from the experiments with other species in that the chilling period was much longer. As a consequence the plant loss on ordinary soil was 81.8% immediately after chilling and 100% after a period in warm conditions. On sterile and treated soil, after transfer to warm conditions, losses were 60 and 58.3% respectively. Thus, even under severe conditions, plant loss was less when the participation of soil microflora was abolished. Looking at the figures in Table 1 on losses of chilled plants after their transfer to a warm greenhouse, we see that on ordinary soil the number of dead plants has almost doubled. With longer chilling periods, there is in some cases a total loss after a period in the greenhouse (pepper, Nerosim cucumbers), but in these cases a large percentage of loss is found on sterile soil as well, which denotes a transgression of the limit of cold resistance characteritstic of the given variety. In the other cases, in which this limit is not reached, no losses were found on sterile soil after transfer to the greenhouse. On treated soil, the loss following transfer rises slightly, but does not exceed 8.2% (Delikatess eggplants). With treated seeds, the loss is greater (30%), but the protective role of the fungicide preparation is nevertheless evident.

Let us consider the different types of plant injury under the various experimental regimes. On ordinary soil, as a rule, the root and root-stem transition zone were injured, and the plant either became recumbent or for a certain period remained upright, supported by the lower portion of the hypocotyl buried in the soil which later, expecially after transfer to a warm place, became infiltrated with fungi and decomposed. The upper portion of the hypocotyl and the leaves, with sufficient moisture in the cold chamber, may appear uninjured. On sterile soil, in cases where a longer chilling period was used, injury symptons first appeared in the aerial portion and were reminiscent of those attendant on death through water deficiency: the cotyledons, leaves and terminal bud gradually withered, there was sometimes a drooping of the upper third of the hypocotyl, and the plant wilted. The root system in sterile soil is externally healthy and white. On soil treated with a fungicide the picture is similar, except that the beginnings of injury to the root system are observed more frequently.

Experiments with melons were performed with watermelon and muskmelon, which were chilled under natural illumination for four days at 8-11° and seven days at 11-13°, and with summer squash which was chilled four days at 10-12° and six days at 5-7° under artificial illumination. Results of an assessment of the condition of the plants after chilling are presented in Table 2 and on Fig. 1, II.

From Table 2 we see that on ordinary soil from 23% (summer squash) to 50% (muskmelon) of the plants died during the chilling period, while on sterile soil there was either no loss or, in the experiment with summer squash, it was equal to 14.3%. Approximately the same picture was obtained with soils treated with a fungicide. Pre-treatment of seeds was less effective, but nevertheless the loss was 13-50% less than without treatment. With transfer of the chilled plants to a warm place, the loss of muskmelons increased slightly, and that of summer squash markedly (to 78.5%). On sterile and treated soil the injurious effect of chilling was smaller. Plants which survived chilling on sterile and treated soil were for the most part without external signs of injury; in plants which were chilled on ordinary soil, however, the cotyledons were strongly wilted and the first leaf showed loss of turgor.

TABLE 3

The Role of Soil Pathogenicity in Cold Resistance of Cotton and Corn

Plant variety	Experi-mental condition	Plant loss, in % on the given soil:			
		ordinary	sterile	treated with a fungicide	seeds treated
Cotton:					
Bairam-Ali	C	38.4	0	13.9	34.8
	W	38.4	0	15.4	37.7
108-F	C	53.7	0	1.4	14.1
	W	59.7	0	10.0	15.5
Egyptian 5904	C	43.9	1.5	0	13.6
	W	43.9	1.5	1.6	18.2
Corn:					
Sterling	C	67.9	32.1	28.1	58.2
	W	92.6	85.7	80.7	87.3
Krasnodar	C	78.6	40.0	28.6	26.1
	W	95.7	85.7	74.3	60.9

Note: C) during chilling; W) after three days in a warm place. Treatment with TMTD.

Chilling of the plants in the presence or absence of the factor of soil pathogenicity affects not only the extent and character of plant loss, but also the tempo of subsequent growth and development. Thus, watermelon and muskmelon plants of the experiment of Table 2 were left in a warm greenhouse for 40 days after the chilling period and the number of flowers which had formed was then counted. It was shown that plants which had been chilled on sterile and fungicide-treated soil flowered earlier than those chilled in the presence of a soil microflora.

The number of flowering plants (in %) is shown in the following table:

After chilling on the given soil	Watermelon	Muskmelon
ordinary	0	59.1
sterile	28.5	88.0
treated with a fungicide	19.0	71.0
seeds treated	9.5	76.0

We have also evaluated the significance of a pathogenic microflora in cold resistance of cotton and corn. The results of chilling these plants on ordinary and pre-sterilized soil are presented in Table 3 and in Fig. 1, IV.

In Table 3 we see that on ordinary soil (during a seven-day chilling at 8-10°) there was a 38.4-53.7% loss of cotton plants, while on sterile soil there was practically no loss. With the exception of the variety Bairam-Ali, in which there was a loss of 13.9%, the same picture is obtained on fungicide-treated soil. In this variety the effect of seed treatment was insignificant. In the other varieties of cotton, seed treatment with a dust preparation of TMTD resulted in a reduction of loss of 30-37% in comparison with that sustained on ordinary soil. By using an undiluted industrial preparation (4 g per kg), an increase in the effectiveness of seed treatment was obtained. In these experiments no significant increase in plant loss was noted when the plants were transferred to a warm place, but such an increase was found where plants were chilled at lower temperatures (6-7°) and for longer periods (11 days).

Much information on extensive loss of seeds and seedlings of cotton sown early may be found in the work of Kratirov [9]. One of the causes of root rot in cotton may be the fungus Rhizoctonia [10].

Corn is quite resistant to cold, but even here, with extended chilling, there is observed an infection of the root system of young and even mature plants which is usually caused by the fungus Pythium arrhenomanes Drech [3, 4, 11, 12]. In our experiments corn plants in the third leaf stage were chilled for 11 days at 6-7°. The treatment proved to be too severe, with the result that even on sterile and treated soil 28-40% of the plants were lost. But even in this case the loss was markedly higher in the presence of pathogenic microorganisms, being 67.9-78.6%. The effect of seed treatment was slight in the variety Sterling, but in Krasnodar losses were cut 35-50%. The protective effect of the fungicides was enhanced by an increase in concentration. Thus, in the variety Sterling, treatment of seeds with an industrial preparation of TMTD (4 g per kg) resulted in a reduction of loss during chilling to 7.9%, and a reduction of loss after transfer to the greenhouse to 56.6%; corresponding figures for variety Krasnodar are 12.7 and 38.2%.

Thus, in soil culture, when plants are chilled in the presence of pathogenic soil fungi, injury occurs before the limits of resistance to cold of the particular plant are reached; these become manifest only in the absence of pathogenic organisms.

TABLE 4

Influence on Pepper Plants of Chilling and of Introduction of a TMTD Preparation into the Soil

Character measured	Novocherkass	Maikop	Bulgarian	Ukraine
Through a 5-day period after chilling (in % of original)				
Leaf fall on ordinary soil	89.0	65.0	69.0	15.0
On treated soil	24.0	19.0	17.0	10.0
Through a 45-day period after chilling on ordinary soil (in % of treated soil)				
Dry weight of aerial organs	27.0	33.2	41.7	74.4
Dry weight of roots	15.5	32.6	29.9	71.5
On treated soil, without chilling (in % of ordinary soil)				
Increase of dry weight of aerial organs	7.3	15.7	27.5	27.4
Increase in dry weight of roots	11.2	29.0	17.8	30.8

All the experiments described above were performed with plants still in the transplantable stage. In order to clarify the role of soil pathogenicity in chilling of mature plants an experiment with peppers of the following varieties was carried out: Novocherkass, Bulgarian, Maikop, and Ukraine.

Plants were grown to the second leaf stage in ordinary humus-containing soil, and subsequently were transplanted into clay containers, one to a container, the controls into the same soil and the experimental plants into soil mixed with a dust preparation of 50% TMTD (0.5 g per kg). Plants were grown in the greenhouse at 20-25° to the beginning of the flowering stage; the plants were watered four times with the complete Hellriegel's solution (100 ml per container). Chilling was carried out at 5-8° under weak artificial illumination at 80% relative humidity for 13 days.

Fig. 2. Effect of a 13-day chilling of pepper seedlings on their subsequent growth (45 days after chilling): A) Novocherkass; B) Maikop; 1) on soil treated with TMTD; 2) on ordinary soil.

In the control plants, all the leaves wilted strongly during the chilling period and their borders began to dry up in the experimental plants, on the soil mixed with the fungicide, the lower leaves wilted slightly. Subsequently the temperature in the chamber was raised to 15° in the course of a day, and all the plants were transferred to a conditioned greenhouse at 25° and 80% humidity. The wilted leaves dried up and fell. In five days in the greenhouse 65-89% of the leaves of plants on ordinary soil fell, and 17-24% of the leaves of the experimental plants fell. (Table 4). Only 10-15% of the leaves of the most resistant variety — Ukraine — fell as a result of chilling; the difference between the control and experimental plants in this variety was negligible.

During a further period in the greenhouse, the experimental plants grew rapidly, while those on ordinary soil were in poor condition. The Ukraine pepper proved to be the most resistant. In the other varieties, the weight of the aerial organs after 45 days in the greenhouse was 25-41.7% of that of comparable parts of plants chilled on soil mixed with a fungicide, and the weight of the roots was 15.6-29.9% respectively. (Table 4, Fig. 2).

The soil treatment in itself had no deleterious effect on the plants; on the contrary, the dry weight of aerial organs as well as roots, was somewhat higher in plants grown on treated soil (Table 4). There was, moreover, no adverse effect of the dust preparation on the formation of reproductive elements; it is, on the contrary, more appropirate to speak of a certain suppression of their abscission after chilling.

The alleviation of effects traceable to pathogenicity of cold soils by means of introduction of a fungicide poses the question of the possiblity of an effect on the plants of the fungicide itself. The high dosage levels undoubtedly exert a braking influence, and we observed this in the experiment with Nerosim cucumbers, when the lot of plants was raised on excessively wet soil (Fig. 1, III c); with further growth, however, these plants overtook the controls and flowered abundantly. In the other experiments, with the designated doses of TMTD, we observed no injurious effect of the fungicide. On the contrary, as we saw in the experiment with peppers (Table 4), introduction of TMTD into the soil increased plant weight. We have already spoken of the superior condition of plant chilled on treated soil as compared to ordinary soil (Tables 3 and 4, and also Fig. 2).

A specially designed experiment in which plants were grown for an extended period under the given conditions [in (a) boxes] showed that 30-36 days after sprouting cucumbers, muskmelons and peppers grown on soil containing TMTD were in even better condition than those on ordinary soil; they had more leaves, were taller, and flowered earlier and more profusely (Table 5). Unfortunately we have no data on the influence on yield, but there is no reason to expect that it would be negative in view of the superior development of plants on soil containing the fungicide.

In the previously described experiments, plants were exposed to lengthy chilling periods and the destructive effect of the cold assessed. In order to evaluate the effect of soil pathogenicity on early stages of chilling, i.e. at injurious levels, experiments were designed in which cucumbers, variety Nezhinsky, were grown to the cotyledon

stage on ordinary and sterile soil and then subjected to a three-day chilling in a light greenhouse at 2°. No external signs of injury were observed.

The roots were carefully freed of soil by washing, and 25 plants were placed for a definite time in 40 ml of distilled water. The extent of injury to the roots during the chilling period was assessed according to the quantity of substances exuded into the water, i.e. according to the intensity of root excretion. The quantity of exuded electrolytes was determined by measurement of electroconductivity, and the amount of organic materials was determined by measureing the amoutn of $KMnO_4$ reduced when it was heated to boiling in the presence of the exudate. The

TABLE 5

Effect of TMTD and Various Soil Treatments on Plants

Plants	Character measured (one plant)	Ordinary	Sterile	With preparation	Seeds treated
Viaznikov cucumbers	Height of plant, in cm	29.2	40.0	40.4	39.3
	Number of leaves	6.4	8.1	7.1	7.7
	Number of flowers	16.0	26.6	30.6	24.4
Persid muskmelons	Height of plant, in cm	30.4	52.6	41.7	32.4
	Number of leaves	5.6	7.0	6.6	5.4
	Number of flowers	2.0	2.9	2.7	1.1
Bulgarian peppers	Height of plant, in cm	5.3	9.1	7.1	5.6
	Number of leaves	6.1	8.7	7.7	6.3
	Number of flowers	0	0.8	0.5	0

presence of organic substances in root exudates was also detected by testing for peroxidase activity using the benzidine method which is good for small enzyme concentrations. This enzyme has been found in root exudates by Kuprevich [13]. Peroxidase was determined according to the method of Boiarkin [14] in 4 ml of solution containing the roots, and the results were expressed on the basis of 40 ml total volume; the extinction coefficient E of the benzidine solution was 0.125; the solution thickness was 1.6 cm. Under these conditions the enzyme activity A is equal to 78 divided by the time in seconds required for the reacting mixture to develop color of an intensity equal to that of the standard. The solution analyzed was clear without signs of contamination. As a further check against contamination, a determination was made after the plants had been in water for three hours (variant 2), and an experiment was performed in which plants which had been chilled at 3° for four days were subsequently transferred to water at 3° (variant 4).

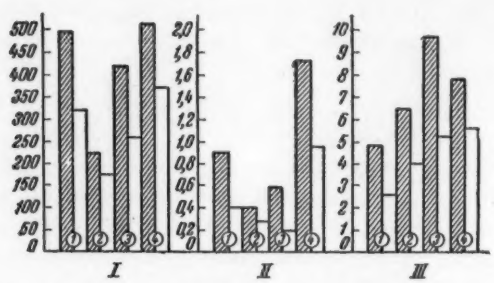

Fig. 3. Root excretion in Nezhinsky cucumbers (cotyledon stage) chilled on ordinary (diagonally hatched) and on sterile soil.
1) Three-day chilling at 2° on soil and one day at 18° in water; 2) the same plants after three more hours at 30°; 3) the same plants after one more day at 18° in water; 4) four-day chilling on soil at 3° followed by two days in water at 3°; I) electroconductivity (sp. cond. × 10^6); II) organic materials (in ml 0.1 N $KMnO_4$ per 25 plants); III) peroxidase activity (A = 78/ time).

The data presented in Fig. 3 show that a short term chilling in the presence of pathogenic soil microflora, without as yet having any effect on the external appearance of the plant, leads to injury to the root system, as evidenced by the increase in the amount of electrolytes and organic materials exuded. These exudates are probably not a specific reaction to pathogenic microflora since they occur also in plants chilled on sterile soil. The possibility is not excluded that the root exudates of chilled plants may play a definite role in the interactions of roots with the microflora in cold soils.

These data, it seems to us, bear striking witness to the fact that pathogenicity of cold soils is a major

factor contributing to the decline of cold resistance in plants in the field. This fact needs to be taken into account in designing experiments to study cold resistance. The possibility of significantly reducing pathogenicity of cold soils is of interest in connection with the cultivation of heat loving plants. In the case of transplanted crops this is easily accomplished by the introduction of fungicide preparations into small growing pots or forcing beds from which the young plants, together with the treated soil, are transferred to the field.

Pathogenicity of cold soils is of significance not only for thermophillic plants but also for more cold resistant plants, such as cereals [15], young orchard plants [16] and others. In the literature, moreover, one encoutners more and more frequently attempts to prescribe fungicide preparations to combat soil pathogenicity. TMTD is recommended to combat decay and death of seedlings of mulberry [17], corn and lawn grasses [18], and also of other crops [19]. The most useful area of application of these preparations in the increase of plant cold resistance will probably be, however, in the cultivation of early vegetables.

Increased soil pathogenicity is ordinarily manifested, then, when unfavorable conditions affect to a greater degree the plant host than the infecting microflora [20, 21]. In this connection it is possible that in some cases chilled plants are infected not only by specific pathogenic organisms, but also by normally nonpathogenic organisms of the Fusarium or Penicillium type, which become pathogenic for plants weakened by the cold.

SUMMARY

1. Pathogenicity of cold soils reinforces the injurious effect of cold on thermophillic plants. Elimination of pathogens leads to a decrease in the percentage of plant deaths occurring during exposure to cold as well as those occurring during a subsequent period in a warm place. Pathogenicity of cold soils should be taken into account in the design of physiological experiments on cold resistance, and also in the cultivation of thermophillic plants.

2. Soil pathogenicity is also manifested during short-term exposures to low temperatures, leading to a heightened excretory activity of roots.

3. Potential cold resistance, depending on the species, variety and physiological condition of the plant, should be distinguished from field cold resistance, depending principally on pathogenicity of the cold soils.

4. Field cold resistance of thermophillic crops may be increased to the level of potential cold resistance by sterilization of soil, particularly by the application of fungicides (TMTD, mercuran). This method may be unhesitatingly recommended for trial in the cultivation of early vegetables. Pre-sowing treatment of seeds with a fungicide is less effective in plant protection.

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CHANGE IN SALT RESISTANCE OF PLANTS DURING ONTOGENESIS

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The resistance of plants to soil salinity does not remain constant throughout the growing period. With the passage of plants through the various developmental stages it undergoes marked changes. According to the view of certain investigators the influence of soil salinity is particularly evident during seed germination and in the early stages of development. Lopato and Komar [1], and Bekker-Rzhevskaia [2] established in experiments with wheat that salt resistance in this plant increases with age. Gushchin [3] came to the same conclusion. In his experiments with wheat and barley it was shown that in wheat salt resistance increased during development, while in barley, on the contrary, it fell, up till the tillering stage, and again rose until the shooting stage. Novikov [4] showed in a growth experiment with cotton, variety Navrotsky, that this variety was most sensitive to salt during seed germination. In subsequent stages of development, in the period of bud formation and flowering, the experimantal plants were not distinguishable from the controls. V. A. Novikov concluded that salt resistance of cotton increases with age. In this plant there are protective adaptations in the form of small glands and hairs in which excess salt is accumulated. The hairs, filled with salt, fall off and thus free the plant of it.

Confirmation of the results of V. A. Novikov is found in the work of Abutalibov [5], who also demonstrated that in cotton salt concentrations toxic at early stages, including the bud stage, do not exert such pernicious effects at later stages.

Amanov has given much attention to this problem. In field experiments with saline conditions he noted that because of the adverse effect of salt on cotton in its early stages, bud formation and flowering were delayed 14 days. Subsequently salt had no marked effect, and the ripening of the bolls occurred at the same time under the various experimental regimes, i.e. at different levels of salinity. Kovalskaia [7], in experiments with tomatoes and lucerne, showed that at an early age and during flowering salt resistance was lower than at other times. At the stage of bud formation it increased. Kling [8] studied the influence of salt on lucerne, tomato and cotton and came to the conclusion that these species are most sensitive during the period of seed germination. With the beginning of photosynthetic activity their salt resistance increased.

From the foregoing facts it may be concluded that plants react differently to soil salinity at different stages in their development. The matter of changes in salt resistance during ontogenesis is of great importance in agricultural practice. In view of this, we decided to set up a series of experiments with tomato, varieties Planov shtambovy, and Alpatev shtambovy, and cotton variety 1298. Our main purpose was to study the influence of soil salinity on plants at various periods in their development, and also to study the effect of varying salinity conditions on plant salt resistance.

According to the data of Iureva [9], who worked on salt resistance of tomatoes, they are quite resistant plants and can easily withstand concentrations of sodium chloride as high as 0.2% of the dry weight of the soil. A small concentration, up to about 0.06%, not only does not suppress growth but even stimulates it.

METHODS

Experiments with Planov shtambovy tomatoes were carried out in pots containing 9 kg of soil. A mixed sand and clay soil was used. Before being placed in the pots fertilizer as added – 1.4 g superphosphate and 0.28 g $(NH_4)_2SO_4$ per 1 kg dry soil. Tomato seeds were sown in flat planters. When the seedlings were 12 cm high, they were transplanted

into the pots. Throughout the experiment soil moisture content was maintained at 70% of the saturation level. Soil salinity was controlled by addition of sodium chloride dissolved in the irrigation water; the salt was given in one application at various stages in the plant's development (early stage, bud stage, and flowering stage). The salt concentration used was 0.2%, based on the chloride moiety, of the dry weight of the soil.

Gross examination of the plants was made throughout the growing period. The fruit was harvested on October 16 (Table 1).

TABLE 1

Fruit Yield of Tomatoes Variety Planov Shtambovy

Stage of salt application	Plant height, in cm	Number of fruits, per plant	Fruit weight (average of one plant)	Fruit weight, in % of control
Control	74	17	320.0	100.0
Early stage		died		
Bud stage	62	17	294.8	91.8
Flowering stage	57	7	132.5	41.3

As these data show, plant response to a single massive application of salt differed with the developmental stage at which the application was made. With application at an early stage, the effect of the salt was highly toxic. Noticeable salt burns appeared on the leaves. The plants began to lag in growth, and at the inception of the flowering stage they died. With salt application at the bud stage, toxic effects were also observed, but they were less pronounced. Burned areas were found only at the leaf tips. The plants recovered soon after salt application, and subsequently yielded fruit. This treatment, given at the flowering stage, also proved to be injurious. In this case the toxic effects were most marked. A certain time after salt application the plants lost turgor. The leaves, covered with burned areas, withered and shortly fell. Half the experimental plants died, and those which survived gave decreased yields (41.3% of the control).

TABLE 2

Effect of Gradual Application of Salt to Soil of Fruit Yield in Tomato Variety Alpatev Shtambovy

Stage of salt application	Plant height, in cm	Number of fruits, per plant	Fruit weight (average of one plant)	Fruit weight, in % of control
Control	73	6	202	100.0
Early stage:				
single application	42	3	62	30.6
successive application	69	5	207	102.0
Bud stage:				
single application	51	4	125	61.0
successive application	70	6	184	91.0
Flowering stage:				
single application	66	4	117	57.9
successive application	71	5	201	99.5

In the next experiment, we run one series of plants to which salt was applied in a single dose and another series in which the same amount of salt was applied gradually in several successive doeses over a period of 10 days (five times a day); applications were made at various stages of development. The salt concentration used, based on chloride – 0.1%. Experiments were performed with tomato variety Alpatev shtambovy in sand culture. We used Hellriegel's nutrient solution as modified by Khalizov-Remizov see[10].

The fruit crop was harvested in October 6. Yield data are given in Table 2.

A single application of salt caused a decrease in yield in tomatoes of this variety. A particularly marked effect of salt was noted when the application was made at an early stage or at the flowering stage. When salt was given at the early stage, fruit yield was 30.6% of the control, and when it was given at the flowering stage, yield was 57.9% of the control. When the salt was applied over a 10-day period, no signs of plant injury were observed, regardless of the stage at which the application was made: the yield was approximately the same as that of the control plants grown in the absence of salt. Therefore, with gradual addition of salt, the plant's resistance increased perceptibly.

We than decided to determine the effect of application of a weak salt concentration (0.05%) prior to sowing on Alpatev shtambovy tomatoes. The experiment were carried out in sand cultures, using the modified Hellriegel's solution. Sodium chloride was added to the pots prior to filling them with sand. The final salt level was 0.1%, based on chloride.

TABLE 3

Effect of a Weak Pre-sowing Application of Salt to Soil on Yield in Tomato Variety Alpatev Shtambovy

Stage of salt application	Plant height, in cm	Number of fruits, per plant	Fruit weight (average of one plant)	Fruit weight, in % of control
Nonsaline background				
Control without salt	76	7	456	100.0
Salt applied: at an early stage	42	3	121	26.5
Bud stage	61	5	281	61.5
Flowering stage	60	–	–	–
Saline background				
Control, on weakly saline soil	63	6	436	95.5
Salt applied: at an early stage	62	5	397	87.0
Bud stage	68	7	382	83.7
Flowering stage	74	7	378	82.8

The tomato plantings were grown in dishes containing sand with the same nutrient mixture which was subsequently used in the pots. For a weakly saline background the plants were grown in the presence of 0.05% salt. Salt application to experimental plants was made, as in the previous experiments, at various stages in the plant's development. The fruit was harvested on September 21. Because of the rainy weather the fruits, although of normal size, did not ripen, and they were collected in this condition.

Yield data from this experiment are presented in Table 3.

The results presented in Table 3 show that a weak pre-sowing application of salt exerts a favorable effect on the salt resistance in tomatoes. The plants, from the very earliest stage, are adapted to sodium chloride in the

nutrient medium, and subsequently prove to be less sensitive to salt at the 0.1% level.

In this experiment, when salt applications were made to soil which had not been given a pre-sowing application, the fruit yield was lowered (see Table 3). Thus, for example, when salt was applied at an early stage the average fruit weight for 1 plant was 26.5% of the control. With application at the bud stage, it was 61.5% of the control. With application at the flowering stage the plants died.

When a pre-sowing salt application had been made, no signs of injury to plants were observed. The plants gradually assumed a succulent character, the leaves became fleshy and thick, with dark green color. The plants remained healthy until the end of the growing period and fruited normally. Furit yield in these plants was a little lower than in control plants, but the sensitivity of the plants to salt application at various stages of development was markedly lowered.

Experiments with cotton. Cotton is one of the most important commercial crops. For a long time it has attracted the attention of investigators. Being a thermophillic crop with an extended vegetative period, it can grow only in regions with a long growing period. In the USSR the principal cotton growing regions are the central Asiatic republics in the Transcaucasus, i.e. regions where extensive areas of fertile soil are saline and are little suitable for agriculture. The problem of cotton culture is therefore related to the problem of increasing its salt resistance. According to published data, cotton can effectively withstand soil salinity. Bolls [11] is of the opinion that cotton can be considered a facultative halophyte. Novikov [4, 12] observed in cotton grown on saline soil a change in anatomical-morphological features, which gave it a halophytic character. Rozhanovskii[13] observed in cotton grown in saline conditions the appearance of smaller cells in the epidermal layer, closing of stomates, increase in number of stomates per unit area, thickening of exterior walls of epidermal cells, and appearance of leaf succulence associted with thickening of the mesophyll layer and increase in the intercellular spaces.

In spite of the comparatively high salt resistance of cotton, its yield on saline soils is strongly depressed. Burygin [14] observed a decline of yield in cotton in many varieties he investigated. Kovda [15] has also noted a decline in the quality of raw cotton produced on saline soil.

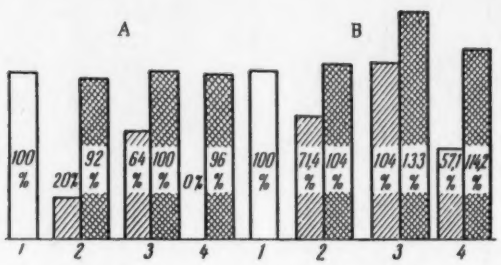

Fig. 1. Number of fertile elements in cotton variety 1298 on nonsaline (A) and saline (B) soils: 1) control without added salt; 2) salt applied at a young stage; 3) at the bud stage; 4) at the flowering stage. Diagonally hatched – single application; cross hatched – gradual application.

As in the experiments with tomatoes, our aim was to study the change in salt resistance of cotton as its development progressed, and also to study salt resistance as it is related to various methods of salt application.

Experiments were performed with cotton variety 1298, grown in pots containing 8 kg of soil of a mixed sand and clay type. Soil moisture content was maintained at 70% of the saturation value throughout the experiment. Plants were grown on soil to which no pre-sowing application of sodium chloride was made, and on soil to which a weak application was made. In the pre-sowing treatment, the salt was added to the soil at the time the pots were filled at a concentration of 0.05%, based on chloride. The salt was applied in two ways: in a single dose at different stages in the plant's development, and gradually in a series of small doses over a period of 10 days, the dose series being given at the corresponding times in the plant's development.

Data on the number of fertile organs present on August 25 are presented in Fig. 1.

Results of an experiment with cotton 1298 show that salt resistance in this variety is strongly dependent on age and method of application of salt. This pattern is particularly striking where there was no pre-sowing application. With a single massive application at a young age, the plants showed a marked decline from the control level in the number of fertile elements (20%). Leaves showed extensive salt burns, and the plants began to lag in growth behind those not exposed to salt. With a single application at the bud stage, the number of fertile elements was 64% that of the control; leaves showed burns, but to a smaller extent than when salt was applied at an early

age. Gradual application in this period had no injurious results. A single application at the flowering stage was particularly injurious to the plants. They lost their turgor and had not recovered by the end of the growing period. The superiority of the gradual method of application is most strikingly demonstrated at this period.

In spite of the fact that it had been shown in numerous experiments that plants become extremely sensitive to unfavorable environmental conditions during the flowering stage, gradual application of salt during this time had no adverse affect. The number of fertile elements was only slightly lower than in controls (96%), there were no leaf burns, nor any other signs of injury.

With a pre-sowing application of salt, the same pattern emerged, except that the adverse effect of a single application at an early stage and at the flowering stage was much less noticeable. A decline in the number of fertile elements was nevertheless observed (with a single application at an early stage, it was 71.4% of the control, at the flowering stage – 57.1%), but the plants survived to the end of the growing period, and indeed salt application did not markedly suppress the plants.

We based our determinations of the degree of salt resistance on the condition of the plant, fruit yield and size of the green mass of the plant. In addition to this method, however, we adopted the microscopic method proposed by Genkel'[16]. Salt resistance is expressed as the percentage of living plasmolyzed cells in the microscopic field. Each determination was based on 30 observations.

The resistance of the protoplasm of cells of the upper epidermis of leaves from tomato variety Planov shtambovy to a 17-hour exposure to salt is seen in the following data: control 14, at an early stage 22, in the bud stage 57, in the flowering stage 23.

As the data show, here was a large percentage of cell deaths in control plants grown on nonsaline soil. After a 17-hour exposure to a molar solution of sodium chloride, only 14% of the cells were living. A small resistance was also found with exposure at an early stage (22% of living cells) and in the flowering stage (23%). In the bud stage, cell resistance was higher: 57% of the cells survived. Similar results were obtained in experiments with cotton.

The resistance of epidermanl cells from leaves of cotton 1298 to a 12-hour exposure to a molar solution of sodium chloride, where the plants have previously received salt applications at the designated stage of development, can be assessed from the following data (% of living cells):

Control without application of salt	8	54
Early stage:		
applied in a single dose	16	47
applied in a series of doses	64	68
Bud stage:		
applied in a single dose	41	53
applied in a series of doses	52	69
Flowering stage:		
applied in a single dose	4	49
applied in a series of doses	50	63

In this case, the same patterns were found as in tomatoes. In control plants on a nonsaline soil, the resistance of the cells was small. After a 12-hour exposure the number of living cells did not exceed 8%. With a single salt application at an early stage, the number of survivors was 16% of the total, while with a gradual application of salt it was 64%. The difference between the two methods of salt application made at the flowering stage is especially striking. In this case, only 4% of the cells survived with a single application, while 50% survived with a gradual application. In the bud stage, the plants were more resistant, and therefore the difference between treatments was not as marked. In a parallel experiment in which there was a pre-sowing application of salt (0.05% chloride), the plants were salt hardened, as a result of which there was a perceptible increase in their resistance. With a single salt application at an early stage, the percentage of living cells, although lowered, was nevertheless not depressed as strongly as was the case where there was no pre-sowing application.

The increase in resistance of tomatoes and cotton which is associated with the gradual method of salt application and with the pre-sowing application of salt may be an indication that salt ions entering the plant bring

about changes in the condition of the protoplasm, as a result of which plants subsequently become less sensitive to soil salinity.

Much work [17-19] has been devoted to the question of the influence of salt ions on protoplasmic properties. More recent investigations [20-22] have established that there is a decline in protoplasmic premeability with a plasmolysis which has been preceded by an initial plasmolysis and deplasmolysis. According to Genkel's data [23], salt ions entering plant cells form unstable compounds with the colloids of the protoplasm and thereby alter its properties. There is evidence of ion binding by protoplasmic colloids and other substances found in the cell in the work of a number of investigators [24-28]. The ability of plants to bind anoins and cations is of very great significance in the process of increasing salt resistance. Among the nonnutritive salts found in saline soils, the cations Na^+ and Mg^+ and the anions Cl^- and $SO_4^=$ occupy a conspicuous place. Plants growing on saline soil therefore undergo changes which are related to the nature of the ion entering from the substrate.

The main purpose of our investigation was to study the changes in the colloidal-chemical properties of the protoplasm in relation to soil salinity and plant age.

When sodium chloride is added to the soil, large amounts of sodium and chloride ions enter the plant. Having a high dispersion ability, sodium ions bring about an increase in colloidal hydrophily, which is externally expressed by the appearance of succulence of the leaves. This has been noted by many investigators in connection with soil salinity [8, 9, 15, 29, 30].

The high level of colloidal hydrophil in plants on saline soil significantly alters the milieu in which physiological processes take place. According to the opinion of Shakhov [31], the protoplams of plants on saline soil contains large amounts of bound water. Since bound water is a poor solvent, physiological-biochemical processes are slower, on the one hand, but on the other hand it serves a protective role, since it impedes the increase in salt concentration of the plant tissues.

We have assessed colloidal hydrophil according to the triangular diagram method of Dumanskii and Dumanskaia [32]. The method is based on the principal of a differential coagulation of colloids in the presence of a mixture of non-electrolytes of which one is a hydrophobic solvent and the other a hydrophilic solvent, these being taken in various ratios. In the presence of alcohol and ether, water extracts of minced leaves are separated into a number of phases; 1) a turbid solution; 2) an intermediate layer; 3) a zone of incomplete coagulation; and 4) a zone of complete coagulation. The more hydrophilic colloids there are in the extract, the greater will be the zone of complete coagulation.

Results of a determination of colloidal hydrophily are presented in triangular diagrams (Fig. 2).

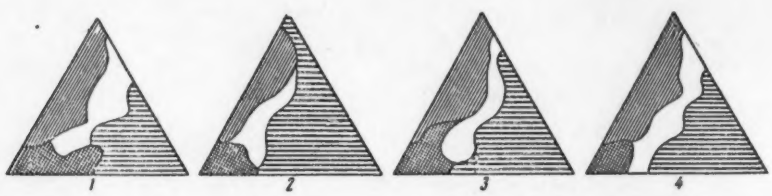

Fig. 2. Hydrophily of colloids of tomato variety Planov shtambovy grown on saline soil (0.1%, based on the chlorine moiety) at various stages of plant development:
1) without added salt; 2) with salt, at a young age; 3) at the bud stage; 4) at the flowering stage. Legend: cross-hatched, turbid solution; parallel lines – intermediate layer; clear – incomplete coagulation; double parallel lines – complete coagulation.

As Fig. 2 shows, colloidal hydrophily is greatly increased in the presence of the chloride. In experiments with tomatoes variety Alpatev shtambovy, there was a very prominent zone of complete coagulation after a six-hour exposure. In plants grown on a nonsaline soil,, the zone was comparatively small (Fig. 2, 1). In plants

grown on saline soil the colloidal hydrophily had increased greatly during the early stages of growth and the bud stage (Fig. 2, 2). It decreased from the bud stage to the flowering stage; the zone of complete coagulation was of approximately the same size as in the controls (Fig. 2, 4). Similar results were obtained in experiments with cotton.

The increase of colloidal hydrophily in plants on saline soil brings about a change in protoplasmic viscosity. The latter plays a prominent role in the process of increasing resistance to unfavorable environmental factors. There is evidence in the work of Genkel' and Tsvetkova [33] that the cold resistance of plants is increased when the protoplasmic viscosity is artificially increased.

We have determined protoplasmic viscosity by the method of plasmolysis with sucrose [34]. Data on protoplasmic viscosity in tomato, variety Planov shtambovy, are presented in Table 4.

TABLE 4

Protoplasmic Viscosity in Tomatoes Variety Planov Shtambovy

Soil	Stage of development	Leaf number	Min. to beginning of concave plasmolysis	Min. to beginning of rounding up of of protoplast
Nonsaline	Early stage	2	4	10
Saline			7	48
Nonsaline	Bud stage	4	4	11
Saline			8	62
Nonsaline	Flowering stage	5	3	8
Saline			5	9

TABLE 5

Resistance of Cells of Tomato Variety Planov Shtambovy to High Temperature

Soil	Stage of development	Temperature of protoplasmic coagulation
Nonsaline	Early stage	50
Saline		52
Nonsaline	Bud stage	52
Saline		54
Nonsaline	Flowering stage	48
Saline		50

We determined the resistance of plants to high temperature by the method of Genkel' and Tsvetkova [33]. Data from this determination are presented in Table 5.

As Table 5 shows, protoplasmic coagulation occurs at a higher temperature in plants grown on saline soil than on those grown on nonsaline soil. The age of the plant also plays an important role. In our experiment, plant resistance increased from a young stage to the bud stage; upon transition the flowering stage it fell sharply. According to Genkel' [16], protoplasmic elasticity is of great significance in determining the capacity of plants to withstand dehydration. By elasticity is meant the ability of the protoplasm to return to its original condition after deformation. In nature, deformation of protoplasma may be seen during strong cellular dehydration in periods of drought. Consequently the greater the elastic properties of the protoplasm, the more resistant the plant will be to dehydration. We determined protoplasmic elasticity by the method of Genkel' and Margolina [34]. The data from this determination are presented in Table 6.

As the table shows, protoplasmic elasticity is markedly lower in cotton grown on saline soil than in control plants. In plants from nonsaline soil, 26-30 minutes are required for complete contraction of the protoplasm away from the walls, while 12-16 minutes are required in plants from saline soil, where they are at an early stage or in the bud stage. In the flowering stage, protoplasmic elasticity is markedly higher both in plants grown on nonsaline soil and on saline soil.

TABLE 6

Protoplasmic Elasticity of Cells of Cotton Leaves (in min.)

Soil	Stage of development	Leaf number	Beginning of contraction of protoplasm from cell walls	Complete contration of proto-plasm
Nonsaline	Early stage	2	20	26
Saline			5	12
Nonsaline	Bud stage	5	20	30
Saline			8	16
Nonsaline	Flowering stage	6	None	None
Saline			14	25

SUMMARY

The reaction of plants to unfavorable environmental conditions depends on the stage of development of the plant. Salt resistance of plants can either increase or decrease depending on the physiological state characteristic of the developmental stage of the plant.

The salt resistance of young plants was found by us to be small. A sudden increase of the salt content of soil which had previously had a normal salt content, strongly poisoned tomato and cotton plants, and their growth and development were subsequently retarded. In separate experiments with young tomatoes, variety Planov Shtambovy, plants remained alive after salinization before flowering set in and rapidly died during this stage. In the bud stage salt resistance of the plants was much higher than at an earlier age.

The largest decrease of salt resistance was observed during the flowering stage. At this period even salt resistant plants suffered from salinization. In our experiments we observed appreciable salt burns, loss of turgor, falling of leaves and death of the plants. The mode of introduction of the salts is important for increase of the salt resistance. If the salt concentration is suddenly increased, poisoning of the plants is observed and the crop yield appreciably drops. If salinization occurred before the plants were sown and increased by small degrees over a prolonged period, the plants gradually became resistant and subsequently becomae less susceptible to the adverse effect of soil salinization.

The stage of the protoplasmic colloids is greatly affected by soil salinization. The state of the colloid system depends on the nature of the salt ions in the soil which subsequently enter the plant organism. A large increase of hydrophily of the colloids is observed under conditions of chloride salinization. Sodium and chlorine ions absorbed by the plant facilitate the accumulation of large amounts of bound water. Increase of the hydrophilic properties of colloids is especially noticeable in young plants. Hydrophily of the colloids gradually decrease with age. During the flowering stage the degree of dehydration of the colloids is maximal and approaches that of plants grown on nonsalinized soils.

The protoplasm viscosity sharply increases in plants grown on soils with an excess of chloride salts. Upon transition to the flowering stage the protoplasmic viscosity sharply decreases. Our experiments thus clearly demonstrate the correlation between viscosity of the protoplasm and the degree of hydrophily of its colloids.

Plants with protoplasm of higher viscosity are distinguished by their greater resistance to the effects of high temperatures. Young plants and plants in the bud stage grown, on salinized soils were especially resistant. Upon transition to flowering the resistance of plants decreased. Control plants grown on nonsalinized soil were very weakly resistant to high temperature.

Soil salinization lowered the elasticity of the protoplasm. As a consequence the plants lost their ability to resist the dehydrating action of atmospheric and soil drought. It has been found that only during the flowering stage when the viscosity and hydrophily of the colloids decrease does the elasticity of the protoplasm increase.

Evidently the decrease of the elasticity of the protoplsam is due to an increase of hydrophily of the colloids which causes a weakening of the bond between the protein molecules and between these molecules and the cellular walls.

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BRIEF COMMUNICATIONS

THE INTERRELATIONS OF SHOOTS OF A TUFT OF MEADOW GRASS

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The interrelations of individual shoots in a tuft of a perennial grass has long been a subject of interest to meadow culture biologists. In the development of methodsof creating a grass stand for a definite purpose – grain, hay, or pasturage – the establishment of the existence of physiological bonds between shoots of various ranks within a tuft of a perennial grass assumes particular significance. Smelov [1, 2, 3] has demonstrated this unequivocally. The attractiveness of a method using labeled atoms led us to undertake to demonstrate the same thing in this way.

This work was completed at the experimental base of the V. R. Williams All-Union Scientific Investigation Fodder Institute. The work was carried out with radioactive phosphorus P^{32} with a specific activity of 7.6 μc/ml. This concentration was harmless to the plant but at the same time was high enough to permit detection of P^{32} at sites removed from the site of absorption. P^{32} was introduced into the plant by application at sites remote from the roots as well as by application to the roots themselves. The work with P^{32} was performed according to the accepted manner with the given form of radioactive isotope.

Certain peculiarities of the method of application of the P^{32} to our object led to the following procedure. First, the shoots of different ranks in the tuft to be treated with P^{32} were bound with theads of different colors. In a given experiment the P^{32} was introduced into a shoot of some particular rank – primary, secondary or tertiary. Near the shoot to be treated, in the immediate vicinity of the tuft, a hole was dug which was large enough to contain a small porcelain dish. Into the dish was poured a solution containing P^{32} (Na_2HPO_4). The shoot was carefully bent and completely immersed in the solution for 5 minutes, after which it was allowed to return to its original position. The unabsorbed drops of solution ran into a dish placed under the shoot. After the liquid had evaporated from the leaf surfaces, the shoot was carefully enclosed in a wide transparent test tube. The shoot remained thus until the time the tuft was dug up and prepared for further analysis. Enclosure of the shoot in a test tube prevented loss of P^{32} from the leaf surfaces in rain or dew with a subsequent entrance into the soil and the plant's roots. The shoot contained its photosynthetic activity under these circumstances; air had full access to the shoot, i.e. the normal processes of the shoot and the tuft as a whole were not disturbed. The work was carried out during the early morning hours. After two days the tuft was dug up, divided into shoots of different ranks according to the purpose of the experiment. After the individual parts of the tuft of the shoot were cut up, they were placed in a counting apparatus. The results are expressed in counts per minute per g dry weight. The plant used was two-year-old meadow timothy.

In Table 1 are presented data illustrating the transport of P^{32} from a primary shoot (axial) to secondary and tertiary shoots, as well as data on the localization of P^{32} in the various parts of the shoots; P^{32} was given to the axial shoot by application to a site remote from the roots.

It can be seen in Table 1 that P^{32} administered to a primary shoot is transported not only to neighboring secondary shoots, but even through their tiller nodes to tertiary shoots; it is localized in tiller nodes, roots, and leaves.

Radioactive phosphorous was also applied by the same method to younger shoots, i.e. tertiary shoots, and its path to secondary and primary shoots was followed (Table 2). The amount of P^{32} is given for the shoot as a whole without further breakdown.

TABLE 1

Movement of P^{32} From a Primary Shoot to Secondary and Tertiary Shoots and Its Distribution in Various Parts of the Shoots in Meadow Timothy*

Shoots and organs	P^{32} content, in counts per min per g dry wt in different tufts		
	first	second	third
Primary shoot (reproductive) with P^{32}			
leaves	97318	84778	69062
stem	942	4722	1032
reproductive organs	560	931	traces
tiller nodes	647	2186	1789
roots	1118	1792	1154
Secondary shoot (reproductive) without P^{32}			
leaves	231	372	829
stem	107	142	193
reproductive organs	none observed	traces	traces
tiller nodes	336	603	491
roots	739	877	684
Tertiary shoot (short) without P^{32}			
leaves	311	traces	1026
tiller nodes	322	traces	1439
roots	344	traces	1470

*P^{32} given to the primary shoot August 6, 1955, by application to a site remote from the root.

TABLE 2

Movement of P^{32} from a Tertiary Shoot to Secondary and Primary Shoots in Meadow Timothy*

Shoot rank	P^{32} content, in counts per min per g dry wt in different tufts		
	first	second	third
Primary, without P^{32}	5116	315	281
Secondary, without P^{32}	4152	228	230
Tertiary, with P^{32}	79315	41545	22678
without P^{32}	–	2224	411

*P^{32} given to the tertiary shoot August 6, 1955, by application to a site remote from the root.

The figures of Table 2 bear witness to the translocation of significant quantities of P^{32} from the tertiary shoot not only to the neighboring secondary shoot but also through its tiller node to the primary shoot. There was also movement into the other tertiary shoots which had not received P^{32}.

At the end of the summer and the beginning of autumn the short tertiary shoots in meadow timothy are characterized by a large quantity of green leaves; there are almost no dead or dying leaves, as is the case with secondary and primary shoots. It may therefore be conjectured that the youngest shoots, possessing a large photosynthesizing surface consisting of young healthy leaves, form significant quantities of plastic materials which are utilized by the older shoots.

The feasibility of a considerable translocation of radioactive phosphorus from younger to older shoots was

shown even when the P^{32} passed through individual roots on the tertiary shoots (Table 3).

In Table 3 it may be seen that even with passage of P^{32} into adventitious roots on the tertiary shoot, its intensive translocation into older shoots in large quantities takes place; its movement is very rapid – in our experiment it was accomplished in 12 hours from the moment of immersion of the roots in the P^{32} solution.

TABLE 3

Movement of P^{32} from Adventitious Roots on Tertiary Shoots to Older Shoots in Meadow Timothy

Shoot rank	P^{32} content, in counts per min per g dry wt in different tufts			
	first	second	third	fourth
Primary, without P^{32}	825	363		
Secondary, without P^{32}	293	2050	15102	15451
Tertiary, without P^{32}	271	363		
Tertiary, with P^{32} (through adventitious roots)	2139	25292	58166	37124

The results presented establish the existence of active physiological relations among the shoots of different ranks within a tuft of perennial grass. Thus, there is translocation of materials not only from older to younger shoots, but also from younger to older shoots.

It was also shown that translocation of phosphorus compounds occurs easily and rapidly through a series of nodes from a tertiary shoot to other tertiary shoots and to secondary shoots other than that from which the treated shoot arose.

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THE SEASONAL RHYTHM OF ABSORPTION AND EXCRETION OF MINERAL NUTRIENTS BY ROOTS OF WOODY PLANTS

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In the cultivation of the principal woody plants it is necessary to know among other things the characteristics of absorption and excretion of mineral nutrients by the root systems of the various species. The interactions of species are to a significant degree determined by the various times and levels of activity of absorption and excretion [1]. Each species has its own rhythm of activity, which is determined by the alterations of the external environment.

It is known that there are two cycles of absorption and excretion in plants: seasonal and daily. These processes have as yet been studied only slightly in woody plants. Recently some interesting papers on this matter have appeared [2, 3 and others], but the experimental data are insufficient. In this connection, the purpose of the present work is the study of the seasonal cycle of absorption and excretion of phosphorus of certain woody plants.

Experiments were performed in 1954 and 1955 with two-year-old plants of oak, linden, pine, birch, yellow acacia and others grown on sandy soil and in pots filled with sand. We evaluated the physiological activity of the root systems in terms of the amount of labeled phosphorus (from K_2HPO_4) absorbed in one day at various times during the growing period by the complex of fine roots where ordinarily all the physiological activity occurs.

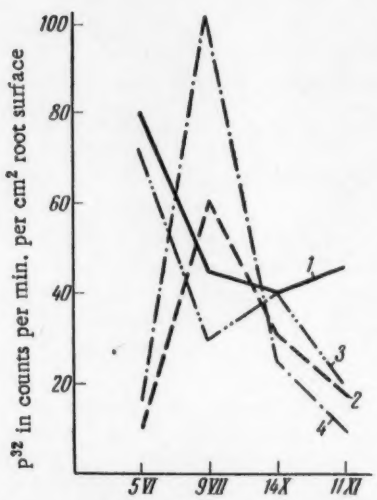

Fig. Absorption by thin roots of woody plants of labeled phosphorus (in a 24-hour period of exposure to the solution) at various times in the growing period (in countes per minute per cm^2 root surface).
1) Oak; 2) linden; 3) birch; 4) pine.

The intensity of excretion was assessed according to the level of radioactivity of the solution in which the root system of the experimental plant was immersed. The labeled phosphorus was introduced into the plant through the leaves in some cases and through an isolated portion of the root system in other cases.

Experiments were carried out throughout the growing period at four times which were fixed at a definite phase of the plant's development. The specific activity of the solution used in absorption studies was 0.02 microcurie per ml, and for studies in which the labeled phosphorus was introduced through the leaves – from 0.2 to 1 microcuries per ml.

In the experiment on absorption of labeled phosphorus by the roots, after a 24-hour exposure to P^{32} the root systems were carefully washed first in a solution of superphosphate and then for 10 minutes under running tap water. Each plant was then divided into parts: branches, stems, and thick and thin roots. Thick roots were those 1 mm or more in diameter, thin roots, less than 1 mm in diameter.

TABLE 1

Intensity of Absorption of Labeled Phosphorus by Root Systems of Plants at Various Times in the Growing Period (during a 24-hour exposure to the solution; radioactivity of individual organs in thousands of counts per min per g dry wt)

Plant organs	Oak				Linden				Birch				Pine			
	5.VI	9.VII	14.X	11.XI	5.V	9.VII	14.X	11.XI	5.VI	9.VII	14.X	11.XI	5.VI	9.VII	14.X	11.XI
Thin roots	276,4	164,8	108,9	220,9	44,9	283,6	84,3	84,4	304,1	125,6	168,9	84,0	26,2	471,2	119,9	46,8
Thick roots	72,3	51,3	15,9	43,6	80,2	185,6	89,3	18,7	75,3	106,2	51,4	24,2	12,7	196,3	31,7	11,2
Stems with branches	28,5	5,2	1,4	1,7	70,9	42,1	6,3	0,8	53,5	195,0	3,5	0,8	47,1	269,2	22,2	0,5
Leaves or needles	22,7	0,3	1,9	—	11,0	6,7	2,7	—	245,7	236,1	1,9	—	55,9	220,3	9,2	0,1
Average for the whole plant	124,8	69,8	31,4	74,5	51,0	113,3	42,0	34,1	168,2	141,2	57,4	12,8	54,8	260,1	38,5	13,4

The study on excretion of labeled phosphorus by the roots was carried out in two ways. In the first – the labeled phosphorus was introduced into the plant through an isolated portion of the root system and subsequently the radioactivity of various parts of the plant and of the water solution surrounding the untreated portion of the root system was determined. In the second, the radioactive phosphorus was introduced three times in a 24-hour period into the leaves, after which the radioactivity of the various parts of the plant and of the water solution surrounding the root system was determined. These experiments were performed in triplicate. Determinations of radioactivity were made in the course of a day. Corrections for background count and radioactive decay were made.

The results of the investigation of absorption and excretion of labeled phosphorus by the root systems of woody plants at various times in the growing period are presented in Tables 1 and 2 and in the figure.

Tables 1 and 2 show that these processes are extremely variable in the course of the growing period. Maximal and minimal activities of absorption and excretion of labeled phosphorus are related to a definite time in the growing period. Thus, in oak absorption is maximal at the beginning of June, and in linden it is minimal at this time. In July, absorption reached a maximum in linden, while in oak it had sharply declined at this time. In November, it once more rose sharply in oak. Approximately the same pattern was observed in birch and pine. The seasonal rhythm of phosphorus absorption in birch was analogous to that of oak. Maximal absorption occurred in June, while in pine it was minimal at this time. In July, it reached a maximum in pine while by this time it had shrply decreased in birch. In November it rose markedly in both species.

The data obtained enable on to say that oak in combination with linden, and pine in comination with birch, will make smaller demands on the soil than would pure stands of the species in question, since in mixed stands the uptake of nutrient reserves, in particular phosphorus, is more evenly distributed. In mixed stands of oak and pine, or linden and birch, however, their phosphorus requirements will concur to a greater extent inasmuch as the absorption maxima of the members of a pair occur at one and the same time. Our investigations showed that during the period of maximum growth of the active roots there is also maximum absorption of mineral nutrients. It is therefore often possible to judge the intensity of absorption by the rate of growth of the active roots in a season.

The data also showed that the species studied not only absorb phosphorus but excrete it into the surrounding medium at definite times in the growing period. In this connection the intensity of excretion varies with the species. The most active excretion was observed in linden and pine, while it was perceptibly weaker in oak and birch.

As with absorption, excretion activity varies throughout the growing period. In linden it is greatest in June and July, it falls

sharply in October, and once again rises slightly in November. In birch there is an intensive excretion in June and November and it is at a minimum in July (Table 2). It is interesting to note that the maximal absorptive activity in oak coincides with the greatest excretory activity in linden. The same thing is true with pine and birch. Obviously, the improved growth of oak and linden in mixed stands under natural conditions, and also in many cases the improved growth of pine and birch, can be attributed in marked degree to these physiological peculiarities.

It has been shown in the experiments of a number of investigators that root excretion plays a basic role in the soil nutrition of plants in mixed stands. It is known that one component of a mixed stand may easily incorporate difficultly soluble mineral elements and then given them up to other components, which are unable to incorporate them in the original form, as root excretions. It is certainly true that linden in combination with oak will in known degree improve conditions of phosphorus nutrition, and possibly that of other elements.

TABLE 2

Intensity of Excretion of Labeled Phosphorus During a 24-Hour Period (into an Aqueous Solution) by Roots of Woody Plants at Various Times in the Growing Period (radioactivity of a sediment in counts per min per plant)

Species	Labeled phosphorus introduced into the plant							
	through the leaves				through isolated roots			
	17.VI	14.VII	17.X	11.XI	17.VI	14.VII	17.X	11.XI
Oak	4	157	17	450	7	28	24	60
Linden	2380	1440	71	463	280	85	20	180
Pine	2222	104	383	3109	—	—	следы	—
Birch	28	545	44	236	Traces			
Acacia	No data				—	18	108	30

Our numerous experiments [4, 5] under natural conditions also showed that labeled phosphorus introduced into leaves of linden trees is found in neighboring oaks. Under these conditions the transfer of phosphorus from linden to oak took place to a greater extent than from oak to linden. Hence, in the selection of species for mixed stands, it is important to know these physiological properties, since mineral nutrition of woody species in mixed stands can be regulated by means of controlled selections.

Our studies also showed that root systems of various woody species absorb and excrete phosphorus into the surrounding environment in varying degree. For comparative purposes the absorptive activity of the different species was calculated on the basis of 1 cm^2 of surface of the thin roots (see figure). The highest absorptive capacity of these roots was found in oak, while in linden, birch and pine it was perceptibly lower. This obviously explains the fact that oak, in comparison with the other species, is more hardy in forest culture, although the root system is much more weakly developed than in linden or birch. Thus, a quantitative evaluation of the size of the root system does not completely characterize its absroptive capacity. It is also necessary to know the physiological activity.

From the foregoing it can be concluded that oak and birch belong to one group, and linden and pine to another, with respect to the character of the absorption and excretion of phosphorus. The maxima and minima of these activities occur at different times during the growth period. Oak in combination with linden, and pine in combination with birch will present fewer requirements to the soil than will pure cultures, since in mixed cultures the expenditure of mineral nutrients in a season proceeds more evenly. Moreover, the nutritional regime for phosphorus in mixed cultures is improved as a result of root excretion. The improved growth of woody species in a number of other types of mixed stands can also be explained to a large degree by these physiological factors.

In conclusion it should be noted that knowledge of the seasonal rhythm of absorption and excretion of mineral nutrients by root systems of woody plants and also of their physiological activity, makes it possible to properly utilize intraspecific and interspecific relations of woody species in the development of resistant and highly productive forest plantings.

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UNION AND YIELD OF GRAPE GRAFTS TREATED WITH GROWTH STIMULATORS

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It is known [1-3] that some grape varieties, used as stocks, unite well with scions, and, as a result, a sufficient number of high quality grafts can be obtained; however the grafts are not found to be chlorosis resistant. Chlorosis has lately become a widely distributed and dangerous phenomenon in vineyards. Because of that, it is recommended [1-3] that the stock used be the chlorosis-resistant variety Berlandieri or its hybrids, such as 420 A (Berlandieri × Riparia), 5BB (Riparia × Berlandieri) and others.

According to Dzhaparidze [1-2], Kantariia and Ramishvili[3], it is possible to avoid contamination of grape orchards with chlorosis by using the above mentioned hybrid varieties for stocks. But stems of these hybrids do not unite sufficiently with the scion, and root with difficulty [3-6].

According to the data of Ramishvili [3], under the usual agrotechnical conditions only 35-40% of grafts at best, are successful, which undoubtedly cannot be considered sufficient.

Growth stimulators enhance cell division [7-9], and thus cause formation of new tissue [5, 10, 11], which may serve to improve the union of the grafted components in grapes.

Investigations were carried out in the Department of Plant Physiology of the Georgian SKhI in 1956 (on the experimental farm in Mukhran). The hybrid 5 BB was used as a stock, and the variety Chinuri, as a scion. Heteroauxin and α-naphthylacetic acid, either in the form of dilute aqueous solutions or of paste, were used as growth stimulators.

One part of the grafts was stratified in sand for eight days, while the other part was placed in a hothouse for eight days, after which all grafts were transplanted to the nursery. Our previous experiments established [4, 6] that eight days was quite long enough to keep the treated grafts in the hothouse (as against the 15 days specified by current recommendations).

In some of the experiments, the components to be grafted were treated by soaking in an aqueous solution of growth stimulators. In Experiment 1 (see table), stocks and scions were treated for 24 hours with an aqueous solution of heteroauxin (40 mg/l). After this, the grafting was done. One part of the grafts was placed in a hothouse, and the other was stratified in sand, after which all were transplanted to the nursery.

The stratified grafts gave a 46% yield and the hothouse treatment gave a 53% yield, as against 40% and 51% for the corresponding controls (see Table, Experiment 1).

Qualitative indicators were somewhat better in those grafts which were placed in the hothouse prior to transplanting into the nursery.

Grafts treated with higher concentrations of heteroauxin (60 mg/ liter of water) were found to be the best. When stratified, as well as when placed in the hothouse, they gave a similar high quality good yield 69% as against 40% and 51% for the corresponding controls (see Table, Experiment 2). It follows from this experiment that grafts treated with heteroauxin (60 mg/ liter) and stratified give a sufficiently high yield of grafts, and that such treatment of graft components may be considered suitable for practical purposes; the placing of grafts in a hothouse may be considered not to be obligatory.

Grafts treated with the lower concentration of α-naphthylacetic acid (10 mg/ liter) and stratified in

TABLE

Experiments on Grafting and Yield of Grafts

Expt. No.	Solutions with which stocks and scions were treated by soaking for 24 hours prior to the experiment	Treatment of grafts prior to transplanting to the nursery	No. of grafts	Yield of grafts		Separate grafts developed							
						average number of roots		shoots			average weight		Diameter of growth increase (in mm)
								weight		length			
				No.	in %	No.	in %	No.	in %	in cm	in g	in %	
1	Heteroauxin	I	39	18	46	9	112	10	91	38	50	122	7,6
	(200 mg per 5 liters of water)	II	38	20	53	12	171	14	100	55	46	107	7,4
2	Heteroauxin	I	51	35	69	7	87	11	100	43	36	87	7,5
	(300 mg per 5 liters of water)	II	45	31	69	9	128	18	128	51	49	114	8,5
3	α-Naphthaleneacetic acid	I	38	22	58	10	125	18	163	50	47	112	10,0
	(50 mg per 5 liters of water)	II	38	32	84	11	157	23	164	59	54	125	10,0
4	α-Naphthaleneacetic acid	I	40	19	48	11	137	15	136	47	46	112	8,0
	(70 mg per 5 liters of water)	II	49	29	74	11	157	23	164	56	51	118	9,5
5	Control	I	41	16	40	8	100	11	100	45	41	100	7,0
		II	41	21	51	7	100	14	100	47	43	100	8,5
	Stocks treated												
6	Heteroauxin in solution	I	31	19	61	8	100	12	109	48	42	102	9,2
	(200 mg per 5 liters of water)*	II	30	19	63	10	143	20	143	53	47	109	9,1
7	The same as experiment 6, but at a greater concentration of heteroauxin	I	26	18	69	8	100	11	100	48	37	90	6,3
	(300 mg per 5 liters of water)*	II	28	20	71	12	171	23	164	54	53	123	8,8
8	Control	I	41	16	40	8	100	11	100	45	41	100	7,0
		II	41	21	51	7	100	14	100	47	43	100	8,5

* The usual scions were grafted, and the site of the graft was coated with lanolin paste.

Note: I) stratified in sand; II) placed in hothouse.

sand gave a 58% yield (as against 40% for the controls), while those placed in the hothouse gave an 84% yield, as against 51% in the controls (see Table, Experiment 3). The scions took well. The stratified grafts were only slightly inferior to the grafts placed in the hothouse.

Grafts treated with the higher concentration of α-naphthylacetic acid (14 mg/liter) and stratified gave a 48% yield, while those placed in the hot-house gave a 74% yield, as against 40% and 51% in the controls (see Table, Experiment 4). The data presented confirm the fact that grafts treated with growth stimulators and stratified show an increase and percentage of yield as compared with the controls. Even more can be said for those treatments which were kept in the hothouse after grafting; in these, the yield of grafts is considerably increased.

In other experiments, the stocks were soaked in aqueous solutions of growth stimulators, and the usual scions were grafted, while the site of the graft was coated with lanolin past containing heteroauxin.

In experiment 6 (see Table), the stocks were treated with heteroauxin (40 mg/liter) for 24 hours; then the usual (i.e. untreated) scions were grafted, and the graft sites were coated with lanolin paste containing heteroauxin (10 mg/g). At the end of the vegetative period, the data collected showed that the stratified treatment gave a 61% yield of grafts, while the hothouse treatment gave a 63% yield (as against 40% and 51% in the corresponding controls). The same high yield was obtained in the treatment in which the stock was treated with a higher dose of heteroauxin (300 mg/per 5 liters), and the graft site was covered with the same heteroauxin-containing lanolin paste (see Table, Experiment 7). In the stratified treatment, the yield was 69%, while in the hothouse treatment it was 71% (as against 40% and 51% in the controls). A positive effect of heteroauxin was shown in the other indicators also, for example, in the weight and length of shoots, in the average weight of grafts, diameter of growth increase, etc. (see Table).

In the third group of experiments, the basal ends of stocks were treated with the growth stimulator, and the graft site was coated with lanolin paste containing the stimulator.

The morphologically basal ends of stocks were placed into 0.25% aqueous solution of heteroauxin for 24 hours, and after that the usual scions were grafted on. The graft site was covered with lanolin paste containing heteroauxin (10 mg per g). At the end of the vegetative period, the grafts treated with heteroauxin and stratified gave a 43% yield, while those placed in the hothouse gave a 49% yield (as against 48% and 53% in the correspond ing controls). The grafts treated with α-naphthylacetic acid were characterized by very low values of the quality indicators.

It is noted that, both in the controls and in the heteroauxin-treated series, plants which were stratified and those that were placed in the hothouse gave an almost identical yield of grafts.

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INHERITANCE OF SOME PHYSIOLOGICAL CHANGES IN WHEAT INDUCED BY 2,4-D

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We have already reported [1] that spraying wheat plants with a solution of the sodium salt of 2,4-dichlorophenoxyacetic acid (2,4-D) leads to various changes in the structure of leaves, stem and spike. We proposed the possibility of inheritance of several characteristics differing from these of the original plants.

From 1955 to 1957, we have carried out investigations in this direction. The experiments were set up with spring soft wheats: Moskovka 48, Liutestsens 62, and hard wheat Gordenform 432 obtained from the island of Sakhalin, branched Katekhinskaia, as well as winter wheat Moskovskaia 2460 and rye Viatka.

Plantings were made in the experimental field of the Plant Physiology Institute of Lenin's Hills. Plants were sprayed with 2,4-D solution, at the rate of 8 kg per hectare, at the time when they were at the tillering stage.

It must be noted that the use of wider varietal material in these experiments permitted us to find a number of additional morphological deviations which had arisen under the influence of 2,4-D.

In branched Katekhinskaia wheat sessile spikes which remained sterile arose from the uppermost aerial node which carried the main spike. Similar phenomena are described in the literature; they arise sometimes in the cases where wheat plants were placed under conditions of a shortened 7 to 9 hour day [2].

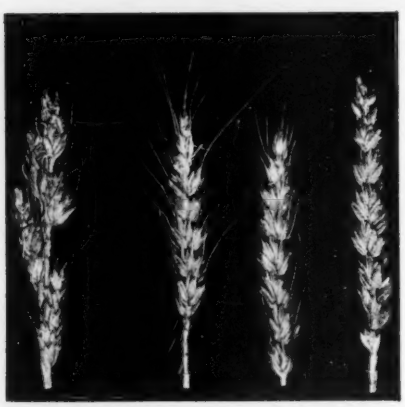

Fig. 1. Changes in the form of spike of spring wheat from the island of Sakhalin, under the influence of 2,4-D in the year of planting.

In plants of winter rye, variety Viatka, cases of the appearance of additional leaves, directly at the base of the spike, were noted under the influence of 2,4-D. Such phenomena were observed by Zabluda [2] in wheat and rye, when the rate of their development was retarded. In the experimental field, with Sakhalin wheat it was found that stalks occurred on a single plant carrying spikes with normally developed beards, and with partial, and with complete loss of awns (Fig. 1). Similar changes in the presence of awns were noted in dwarf wheats during late fall planting [3, 4], smut infection of plants [5], and during budding and rotting of winter wheat, variety Kooperatorka [6]. A few spikes were found with a peculiar form of branching. On the axial spike-bearing stalk, instead of usual spikes, there were distributed four or five separate spikelets whose size decreased from base to the tip (see Fig. 1).

In spikes of experimental spring wheat Moskovka 48, pericarps were found which lacked glumes. This characteristic of naked seed had been noticed by many investigators. Thus, Novikov [7] had obtained naked seeds in oats, when plants which began to undergo the light stage on long day were transferred to short day. Along with the characteristic of naked seed in this wheat there was expressed a stong tendency toward formation of supplementary spikelet scales. They arise under

Fig. 2. Changes in the forms of the spike of spring wheat Moskovka 48 under the influence of 2,4-D and selection. Changes in the different forms from bearded spikes – 1 (1955) into a beardless – 2 (1956) and branched spike – 3 (1957).

the influence of 2,4-D even in the stage of heading, when the spike had already completed its formation. In the literature, a supplementary formation of spikelet scales in the spikes of hybrid plants has been noted [8].

According to our observations, the most labile characteristic in wheats is the presence of awns in spikes, which sometimes disappear during the year of spraying with 2,4-D, as has been shown in the experiments with Sakhalin wheat. The seeds from spikes which lost their awns under the influence of 2,4-D were darker in color than seeds from control plants. In seeds of spikes which lost their awns, protein content was 15%, while it was 12% in the controls. An increase in protein content was noticed by Tumanian [5] after smut infection of wheat plants, which caused loss of awns. A similar relationship between loss of awns in spikes and consequent increase of protein content in grain was found by Ivanov [9].

This new characteristic, lack of awns in spring wheat Moskovka, is firmly established in subsequent generations. Thus, 700 seeds, collected from plants which had lost their awns, when planted in 1957, gave only one plant of which the spikes were bearded. Plants which lost their awns were darker in color than the controls. In the former, the chlorophyll content was 2.07 mg/g while in the latter it was 1.63 mg/g.

Spraying with 2,4-D solutions in subsequent years, together with selection, leads to an increase in the percentage of plants with morphological characteristics changed towards branching and change in spike color. Thus, in 1955 [1], under field conditions, we found 1.84% of plants with morphological changes. Selected seeds from these spikes were planted in 1957. Because of the selection and of spraying, in 1957 the percentage of morphologically changed plants increased to 6%. Fig. 2 shows the gradual transformation of the bearded spike of spring wheat Moskovka 48 (1955) into a beardless and branched spike (1957).

Besides spike branching, on the same plot were found five spikes with violet coloration, and tight non-fragile spikelets. The usual spike color in Moskovka 48 light yellow, with fragile easily shattering spikelet scales. In the agrobiological literature are given much data concerning color change in spikes, which, according to the testimony of geneticists, indicates varietal transformation. The changes of spike color take place during late fall planting of spring wheats, during transformation of spring varieties into winter varieties, and after repeated curring of plants during the vegetative period [10-14].

The effect of 2,4-D on the progeny of seeds is expressed from the moment of seed germination. Thus, the coleoptiles of seedlings in experimental samples have a stronger anthocyanin coloration than those of the control seedlings. If a drop of 10% hydrochloric acid solution is placed on a squashed coleoptile of the experimental seedling, it acquires a pink coloration of a much brighter hue than that of a control seedling. Tumanian [15] reports that, in experiments with artificial infection of individual plants of hard wheats with smut, he obtained seeds which, after germination, resulted in plants with strong anthocyanin coloration, which is inherited.

In 1957, we noted that the progeny grown from seeds acquires a hereditary property resulting in acceleration or retardation of the rate of cereal maturation, depending on the phase of growth during which plants are sprayed with 2,4-D.

In 1956, winter wheat Moskovskaia 2460 was sprayed with 2,4-D solution, at the rate of 8 kg per hectare, on May 14, when the plants had five leaves and the embryonic spike was 1.5 mm long. On a neighboring plot, the spraying was carried out on June 8, when the spike was 5 cm long. After harvesting, the seeds from these two plots were planted separately on September 9, 1956. In the summer of 1957, plants were not sprayed. Phenological observations showed that the progeny of plants sprayed on May 14 became mature earlier. In plants sprayed June 8, a more retarded rate of maturation was observed.

The possibility of obtaining experimentally varieties with different maturation rates was reported by many investigators [16, 17]. Thus, Tumanian [5], by infecting wheat plants with smut obtained plants ranging from very rapidly maturing ones to late-maturing ones.

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CERTAIN CHARACTERISTICS OF METABOLISM IN PINE ROOTS IN RELATION TO THE DEGREE OF SOIL AERATION

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Wide distribution of excess nondraining flooding of forest soils in the north and northwest of our country has a sharp negative effect on the growth and productivity of timber. The metabolism of trees growing in such conditions has up till now been studied very little.

We studied some characteristics of metabolism of pine, in connection with the excess wetting of soil: 1) mineral and nitrogen nutrition; 2) amino acid metabolism in roots. In addition, determinations of protein and nonprotein nitrogen and of chlorophyll a and b content in pine needles were carried out. The assimilation of soil minerals – nitrogen, phosphorus, potassium and total ash – by the plant was studied by analyzing the wood and bark of roots. Amino acid metabolism in roots was studied by means of chromatographic analysis of the xylem sap of roots. The content of chlorophyll a and chlorophyll b in the needles was determined spectrophotometrically.

The main cause for shifts in pine metabolism should be considered not as excess of soil water, but as insufficiency of aeration in the soil. A number of investigators have established the fact that, in soils flooded by nondraining waters, gaseous oxygen is present either in very small amounts [1-3] or is absent altogether [4].

Determination of the content of the main nutrient elements in the wood and bark of roots has shown that a change in the soil aeration regime affects their content in the roots in a substantial way; the excess stagnant water suppresses the rate of assimilation of substances by the root. Assimilation of nitrogen decreases particularly sharply, almost to one-half.

According to the existing data, the assimilation of mineral substances by the plant is directly dependent on the amount of oxygen available and on the energy of aerobic respiration [5, 6] One may suppose, therefore, that the weak assimilation of mineral and nitrogenous substances by pine, under conditions of soil flooding by stagnant water, is a result of aeration deficiency, and that the rate of root respiration is connected with this. Experiments we carried out on the energy of pine root respiration showed that the rate of CO_2 evolutation falls as the partial oxygen pressure in the surrounding gaseous medium is decreased. The rate of root respiration in inert gases decreases to one half and to $\frac{2}{5}$ as compared to root respiration in air. Because of this, it may be considered that the absorption of mineral substances by pine is in direct correspondence with soil aeration and the energy of aerobic respiration of the absorbing organs of trees.

However, the different relationship of ash elements and nitrogenous compounds to anaerobiosis, in the sense of their introduction into a plant, remains unclear. This interesting phenomenon deserves special attention.

It is necessary to note, first of all, that the nitrogen of peat or rough humus forest soils is represented mainly by organic forms. According to the available data [7, 8], it is the nitrogen of monoamino acids. Only 1% to 3% of the total amount of nitrogen in the soil is represented by inorganic nitrogen, amonium. Nitrates and nitrites are absent, as a rule.

Thus, it may be assumed that in the total balance of nitrogenous nutrition of pine growing on the excessively wet soils, the main role is played by organic nitrogen, in particular, the monoamino acid nitrogen.

At the present time, it has been proven that the plant is completely able to absorb the different organic compounds, amino acids among them [9, 10], although there are indications that they are not effective as a source of nitrogen [11]. The latter statement, however, can hardly apply to plants possessing mycorhizae [12, 13].

As was pointed out in the work of Kurzanov, et al [14], the absorption of organic substances by cells is accompanied by a considerable increase in the respiratory process. On the other hand, an increase in respiration is a necessary condition for the absorption of organic compounds, since "the basic cellular respiration, in all probability, is unsufficient, or completely unavailable, for activation of absorption of organic substances." Since in soil saturated with stagnant water the increase in root respiration cannot take place because of the insufficiency or absence of oxygen, a sufficiently rapid absorption of mineral substances by the plant cannot take place either. As a result, a partial, or even complete, blocking of the very forms of nitrogen by which the element is represented in the soil takes place. At the same time, the insignificant reserves of ammonium compounds, which are only weakly supplemented in poorly aerated soils, probably cannot supply nitrogen to the pine in the amount in which trees growing in normally wet soils receive it. Undoubtedly, this is related to the phenomenon that a decrease in assimilation of nitrogenous substances takes place in pine growing on saturated soil, as compared with the assimilation of mineral ions such as calcium, phosphorus, and ash elements.

It is known that a considerable part of the synthesis of a number of products important for the plant takes place in the root [15, 16], and the compounds are then translocated into aerial organs. The root also has the function of coordinating a number of basic metabolic processes of the entire plant [17].

However, these functions of the root system were discovered almost exclusively in herbaceous plants. The question of the synthetic activity of pine roots is, therefore, of considerable interest. We have tried to answer this question by studying the effect of soil aeration on assimilation and approximate content of amino acids translocated in the sap along the xylem from the roots into the stem and crown of the tree. The results of the determinations are summarized in the table.

TABLE

Amino Acids in Xylem Sap of Pine Roots in Relation to Soil Aeration (September 1955)

Stagnant water on the same level of the soil; anaerobic conditions	Stagnant water below the level of root system distribution: the soil is saturated with moisture; semi-anaerobic conditions	The water table is about 1 m from the soil surface; aerobic conditions
		Alanine
Clycine (small amount)	Asparagine	Sorin glycine*
	Glycine	Glutamic acid
		Threonine
	Alanine	Alanine
		Valine

Comparing the gradations of the degree of flooding and aeration of the soil with the amount of amino acids in the xylem sap of pine roots, one can see the following definite rule: a higher level of aeration corresponds to a higher level of amino acid assimilation and vice-versa, which indicates the decisive significance of soil aeration for the synthetic activity of the roots.

Studying the metabolism of nitrogen-containing substances in pine roots, we have succeeded in establishing the fact that almost all the nitrogen of the xylem sap is represented by organic nonprotein compounds; amides are absent. Inorganic nitrogen is represented exclusively by ammonium (traces).

An insufficiency of oxygen supply to the roots has an effect not only on the metabolism of nitrogen-containing compounds in the root itself, but is reflected also in the physiological state of aerial organs. Thus, the amount of chlorophylls a and b in the needles of flooded trees is, on the average, 15% smaller than the content of the same pigment in the neeldes of pine grown under conditions of normal soil aeration. Further, it was possible

* As in original – Publisher's note.

to establish that, in the needles of pine grown in a dry valley, over 90% of the total nitrogen is represented by protein nitrogen, while in the needles of pine grown on an excessively wet soil, protein nitrogen makes up only about 80% of the total. A higher percentage of nonprotein nitrogen in the needles of flooded trees points out the phenomenon of so-called oversupply of this element [18].

All that was said above allows us to conclude that the synthesis of chlorophyll, protein, and evidently, synthesis of other important compounds in aerial organs of trees, in particular in the needles depends, to a great degree, on reactions occurring in the root system of the tree.

Growth of pine plantings on the soils excessively wet with stagnant water should be explained by the general weakening of physiological activity of roots first of all, and of the whole tree in general.

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* In Russian.
** Russian translation.

PREHARVEST DEHYDRATION OF THE AERIAL PART OF POTATO PLANTS WITH THE AID OF CHEMICAL COMPOUNDS

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The mechanization of potato harvesting is one of the most important conditions for the intended increase in the area planted to potatoes.

But the work of the potato-harvesting combine is successful only on condition that the aerial part is already dry. In this case, the combine easily separates the tubers from the haulms without mechanical injury to their surface. However, potatoes must often be harvested when their aerial parts are still green. In this case, the tubers get injured, which then leads to rotting and causes great losses during storage. In addition, the presence of green aerial parts during harvesting, particularly when the weather is warm and wet, favors the development of phytophthora, and of "ring and pearly rot," which leads to great losses of potatoes during storage.

In this connection, the question occurs: is there a way to dry out the aerial part rapidly, in the preharvesting period, by means of treatment with chemical compounds?

In search of a means for desiccation of potato haulms, a number of chemical substances have been tested [1-4]. However, no recommendations concerning the use of chemical desiccants in our potato industry have as yet been made. Also, the question of the physiological changes which take place in potato plants under the action of desiccants remained as yet uninvestigated.

From the number of substances which have already been tested, we took the disodium salt of 3,6-endoxy-hexahydrophthalic acid (endothal), sodium pentachlorphenolate, ammonium thiocyanate, and sodium nitrate [5, 9], and from those that have not as yet been tested as desiccants of potato leaves, magnesium chlorate (hexahydrate), sodium chlorate-pentaborate, and isopropropyl-3-chlorphenylcarbamate. All substances, with exception of the last, were used as aqueous solutions. To increase the wetting capacity of solutions, a wetting agent was added to them, in concentration of 0.25%. Isopropyl-3-chlorophenylcarbamate was applied as a water emulsion. OP-10 was also used as an emulsifier. The latter was used in the same amounts as the active substance. Solutions and emulsions were used at the rate of 1000 liters per hectare of potato planting area. Every substance was tested in several concentrations. Testing was carried out in the experimental field plot of the K. A. Timiriazev Institute of Plant Physiology, of the USSR Academy of Sciences (Moscow, Lenin's Hills). Potato plants, variety Lork were used as experimental plants. Fifty plants were used for each treatment. Treatment was carried out at two times: August 26 (period of termination of tuber formation) and September 14 (period of tuber maturation). Plants were sprayed by means of a hand sprayer. Harvesting took place on September 21. The aerial parts of control plants were green at this time.

From the data of Table 1, it can be seen that a 3% solution of sodium chlorate-pentaborate was found to be most effective in the first period of their treatment, while during the second period, the effective agents were: 0.12% aqueous solution of endothal, 0.56% solution of magnesium chlorate, 1.5% solution of sodium pentachlorphenolate and 1% water emulsion of isopropyl-3-chlorphenylcarbamate. Under the influence of these compounds, the aerial part dried out in 4-5 days. Sodium nitrite and ammonium thiocyanate were weaker in their effect. In the case of the former, a 1.5% solution brought about desiccation of the aerial part in two weeks, while in case of the latter, when a 0.5% solution was used, only the leaves dried out after 11 days of treatment. Analogous data

TABLE 1

Effectiveness of Different Desiccants

Desiccant	Concentration of desiccant in solution, in %	Rate of desiccation of aerial part, in days	Average weight of aerial part per plant, in g	Average weight of harvest per plant, in g	Desiccant	Concentration of desiccant in solution, in %	Rate of desiccation of aerial part, in days	Average weight of aerial part per plant, in g	Average weight of harvest per plant, in g
Chlorate-pentaborate	1.50	6	94	300	Sodium pentachlorphenolate	0.75	7	60	358
	3.00	4	58	289		1.50	4	45	341
Sodium nitrate	1.50	Weak effect	230	347		3.00	4	47	357
	3.00	14	122	330	Isopropyl-3--chlorophenyl-carbamate	0.50	7	60	351
Magnesium chlorate	0.22	7	145	347		1.00	5	57	349
	0.66	4	87	350		2.00	4	45	342
	1.98	4	50	344	Ammonium thiocyanate	0.50	Weak effect	280	354
Endothal	0.12	4	48	339		1.00	The same	250	352
	0.25	4	48	345					
	0.50	4	42	353		2.00	11 leaves	192	342
					Control	—	—	370	355

Note: Treatement of aerial parts by the first two substances was done August 26, and by the other on September 14.

TABLE 2

Effect of Desiccants on the Respiratory Rate of Potato Leaves* (μliters O_2 per hour per g dry weight at 25°)

Treatment	Time of determination after treatment (in hours)						
	$^1/_2$	1	2	3	5	24	48
Control	1376	1385	1410	1395	1430	1348	1422
Magnesium chlorate, 0.66% solution	1112	565	624	561	544	390	321
Sodium pentachlorphenolate, 1% solution	632	500	236	136	150	119	107

*Data given in Tables 2, 3 and 4 refer to the leaves of the middle whorls.

TABLE 3

Effect of Desiccants on the Rate of Water Loss (per hour in % of control)

Experimental treatment	Time of determination after treatment		
	1 hour	2 hours	24 hours
Magnesium chlorate (0.66% solution)	158	193	194
Sodium pentachlorphenolate (1% solution)	97	107	352

concerning the high desiccating activity of endothal and sodium pentachlorphenolate [5, 8] and the weak effect of ammonium thiocyanate and sodium nitrite [6, 7, 9] are given in the literature. As can be seen from Table 1, the weight of aerial parts decreased to one eight after a four day action of strong desiccants, and only to three-fourths or one-half, after the action of weak ones.

If the aerial parts were treated with desiccants after termination of tuber formation (11 days before harvest), the treatment had no effect on the value of yield. However, if potatoes were treated before termination of tuber formation (3 weeks before harvest), the tuber yield was somewhat decreased. This relationship was noted also by other authors [7, 10].

There are data in the literature indicating that desiccation of the aerial parts of potatoes by phenolic desiccants may lead to the darkening of tuber flesh in the region of vessel distribution [8]. Such a phenomenon was not found in a single one of our treatments. In our experiments, application of desiccants had no negative effect on storability, commercial value, or planting quality of tubers.

It follows from Table 2 that the respiratory rate of leaves is decreased within 30 minutes after action of desiccants. It can be seen particularly sharply in the case of sodium pentachlorphenolate. With time leaf respiration continues to decrease, and reaches an insignificant value 48 hours after treatment. By this time, leaves treated with magnesium chlorate respired one-fourth as much as control leaves, while respiration of leaves treated with sodium pentachlorphenolate dropped to $\frac{1}{13}$th that of the controls.

As can be seen from Table 3 desiccants sharply increase water loss, and this takes place much earlier with magnesium chlorate than with sodium pentachlorphenolate. Naturally, the relative dry weight content increases as a result of water loss caused by dessicants (Table 4). This process takes place more rapidly at first than after treatment with magnesium chlorate than when sodium pentachlorphenolate is used. However, on the fourth day, the dry weight content becomes the same in both treatments, and further increase practically ceases.

TABLE 4

Effect of Desiccants on the Dry Substance Content in Potato Leaves (in %)

Treatment	Time of determination after treatment					
	5 hours	1 day	2 days	3 days	4 days	6 days
Control	19.5	18.3	18.2	19.1	19.4	19.4
Magnesium chlorate (0.66% solution)	45.3	43.9	51.4	75.3	75.0	75.2
Control	18.4	19.4	20.8	19.6	19.2	19.6
Sodium pentachlorphenolate (1% solution)	20.0	25.0	35.2	65.4	74.8	75.0

Thus, desiccation of plants obtained with the help of chemical substances represents the result of an irreversible breakdown of metabolism, and a correlated sharp weakening of the water-holding capacity of the tissues. Desiccants cause such a profound breakdown of the living processes of plants that detoxification of the active inhibiting agents cannot take place, and the aerial part of the plant dies as a consequence of poisoning [11, 13].

The following substances may be recommended as effective desiccants, rapidly driving out the aerial parts of potato plants and having no negative effect on the value and quality of tuber yield: endothal (0.12% solution), magnesium chlorate (0.66% solution), sodium pentachlorphenolate (1.5% solution), isopropyl-3-chlorphenylcarbamate (2% emulsion), and sodium chlorate-pentaborate (3% solution). Treatment of aerial parts with these desiccants may be carried out 4 to 5 days before harvesting.

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VARIATION IN THE SEX RATIO OF HEMP PLANTS DUE TO PASSAGE OF AN ELECTRIC CURRENT THROUGH THE SOIL

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The question of differences in activity of oxidation-reduction processes of dindividuals of both sexes in diclinous plants has often been discussed in the biological literature. Most investigators in this field point out that in plants the oxidative processes occur more intensively in male plants than in female [1-7]. Val'ter and Lilienshtern [8] even report that sex can be recognized by this characteristic in young hemp plants, which have not as yet formed the morphological characterisstics of sex differentiation. In some papers, however, there are reports that the oxidative processes are more active in females than in males [9, 10].

Our own experiments [11], with samples of herbaceous monocarpic annuals (spinach, hemp), herbaceous polycarpic perennials (asparagus), and woody polycarpic perennials (alpine currant, actinidia, oblepikha), showed that the male samples of all these species are characterized by higher oxidizing enzyme activity than are the female. Continuing our work, we decided to find out whether the relationship between sex dimorphism and differences in activity of oxidizing enzymes in diclinous plants is sufficiently close to be relied upon when carrying out experiments on sex displacement. In the literature, there are statements that the displacement of sex towards femaleness in diclinous and diecious plants are accompanied by a decrease in the activity of oxidizing processes in tissues of these plants. Using these indications, we attempted to change the activity of oxidizing enzymes in hemp; for this purpose, we used a weak electric current passing through the soil containing growing plants of these species, since, according to our observations, the effect of such currents on some plants (beets, oats) is a depression of oxidizing enzymes. The depression of oxidative enzyme activity should then, according to our opinion, have created more favorable conditions for the formation of female characteristics in hemp, and in this way cause a displacement of the equilibrium between the number of male and female samples toward females.

METHODS

The electric current in the soil was induced by means of the difference in potentials of zinc and carbon electrodes imbedded in the soil and connected by means of an external conductor through an alternating wire resistor. In this case, the soil solution played the role of the electrolyte. For the zinc electrode, we used two zinc plates, 150 × 300 mm in size, connected with each other; as a carbon electrode, four carbon agglomerates from a BNS-MVD-500 battery with manganese depolarizer. The distance between electrodes was 5 m (treatment I) and 10 m (treatment II). The planting beds were 1 m wide. The experimental treatments were separated by protective zones, 3 m wide, while the controls were separated from the experimental plants by a distance of 6.5 m. In addition, individual control treatments were carried on beyond the limits of the experimental plot.

In 1955 the area of nutrition was not measured; in 1956 it was 50 cm^2 per plant.

In the beginning of experiment, the current in the external conductor was held at a level of 10 mA; later, it was decreased to 6 mA. The current flow was not determined in the internal conductor. Careful phenological observations were carried out after planting. During the flowering period, the number of heterosexual hemp individuals was counted, and experiments were made to determine the activity of oxidizing enzymes (polyphenoloxidase and peroxidase) in the leaves of this species.*

* The hemp variety Novgorod-Severskaia was used. The activity of oxidizing enzymes was determined by the method of Mikhlin and Bronovitskaia [11].

For studying the possiblity of hereditary change in the numerical ratio of the different sexes in hemp plants, while an electric current was passed through the soil the seeds collected in 1956 from hemp plants in experimental and control plats were planted in 1957.

EXPERIMENTAL RESULTS

As a result of experiments of 1955-1956, it was established that passing an electric current through the soil has a noticeable effect on the growth and development of hemp plants. This was expressed in decreased energy of seed germination and sprouting, and in retardation of growth, development, and fruit-bearing of experimental plants as compared with controls (by 7 days). In the end of the summer of 1955, when the morphological characteristis of sexual differentiation in hemp were sufficiently clearly pronounced, we carried out experiments to determine polyphenoloxidase and peroxidase activity in leaves of experimental and control plants of this species (Table 1).

TABLE 1

Change of Activity of Oxidative Enzymes in Hemp Leaves with Passage of Electric Current Through the Soil (in ml of 0.01 N solution of I-KI per g of leaves)

Experimental treatment	Plant sex	Polyphenol-oxidase	Per-oxidase	Polyphenol-oxidase-per-oxidase
Distance between electrodes = 5 m	♀	1.20	21.20	22.40
	♂	2.40	24.60	27.00
Distance between electrodes = 10 m	♀	1.60	23.40	25.00
	♂	2.40	26.00	28.40
Control	♀	2.20	27.80	30.00
	♂	2.60	28.60	31.20

TABLE 2

Change in the Numerical Ratio of Individuals of Different Sexes in Hemp After Electric Current was Passed Through the Soil

Experimental treatment	Percentage of plants in 1955			Percentage of plants in 1956		
	males	fremales	ratio of females to males	males	females	ratio of females to males
Distance between electrodes = 5 m	40.9	59.1	1.44	43.9	56.1	1.28
Distance between electrodes = 10 m	49.3	50.7	1.00	43.8	56.2	1.28
Control	47.9	52.1	1.09	47.0	53.0	1.12

These experiments have shown that the activity of the oxidative enzymes in both male and female hemp plants of the experimental treatments was decreased in comparison with that of the controls. A particularly considerable decrease in oxidative enzyme activity was observed in hemp plants grown in the first experimental treatment. In the plants of the second treatment, this change was somewhat lower. The fact the decrease in oxidizing enzyme activity was more noticeable in the female hemp plants of both first and second treatments than in the males deserves attention. The hemp plants of different sexes were counted in the fall of 1955 and 1956 (Table 2).

After counting, it became clear that, in all experimental treatments (except the second treatment in 1955), the number of female hemp plants was increased when an electric current was passed through the soil. This is particularly clearly expressed in the first treatment. In the second treatment, the change of the numerical ratio of female plants to males was somewhat smaller. No intersex forms were observed, either in the 1956 experiments or in the 1957 experiments.

For investigation of the possiblity of hereditary change of the numerical ratio of hemp plants of different sexes after passing an electric current through the soil, the hemp seeds collected from plants of experimental and control plots in 1956, were planted in 1957. Observations have shown that in F_1, as well as in F_0, the experimental hemp plants are characterized by a slower growth and development, as compared with the controls. Counting of the hemp plants of different sexes, carried out during the flowering period, has shown that the change in the numerical ratio of individuals of different sexes, noted during the passage of electric current through the soil, may be regarded as hereditary (Table 3).

TABLE 3

Hereditary Change in Numerical Ratio of Individuals of Different Sexes in Hemp Crop of 1957, After Passage of Electric Current Through the Soil

Seeds planted in 1956	Percentage of plants		Ratio of females to males
	male	female	
From the plants of the first treatment	40.4	59.6	1.48
From the plants of the second treatment	42.3	57.7	1.36
Control	43.4	51.6	1.07

From Table 3, it can be seen that the ratio of individuals of different sexes shifted towards the female in the hemp crop obtained from the seeds of experimental treatments. This shift turned out to be more significant in F_1 than in F_0. The greatest shift of this ratio was noted in plants grown from seeds of the first treatment, and to a somewhat smaller degree, in those from seeds of the second treatment.

The data given above clearly indicate that an electric current passed through the soil causes a shift in the female-male ratio towards the female.

Insofar as specific reasons for this phenomenon are concerned, in our opinion they may be two-fold: 1) the change in the ratio of female to male plants may be connected with a directed change of sex in hemp, which is supported to a certain degree by the data on decrease of oxidative enzyme activity in the experimental hemp plants, as compared with controls; 2) the change in this ratio may be connected with a dissimilar viability of the two sexes in hemp plants (the data indicating a decrease in viability in hemp seeds, following passage of an electric current through the soil can be used in support of this proposal). The data of the experiments of 1955 and 1956 show both of these propositions acceptable to the same degree. The 1957 experiments permit, however, one to consider the first proposition to be more reliable to a certain degree, since the changed ratio of male and female plants in the planted hemp crop acquires a hereditary character.

The results of this work permit one to consider that the relationship between sexual dimorphism and the rate of oxidative processes in hemp is sufficiently close, so that one may depend on it during further investigations of a directed shift of sex in this species.

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THE WINTER DORMANCY OF BUDS AND FROST RESISTANCE OF OF NUT-BEARING TREES

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Different fruit varieties have bud dormancy periods of different durations. Among the fruits grown in Armenia, buds of unaba and oleaster have the longest dormancy period, and buds of cornel the shortest. The nut-bearing trees, as a whole, occupy an intermediate position between these two groups, but the behavior of different species and varieties has not been studied and is not reported in the literature.

It is known from the literature [1-5] that the winter dormancy of buds is made up of two consecutive phases, an intial stage of dormancy, the so-called deep or organic dormancy, and a second phase, the enforced dormancy which takes place after the first phase and continues until the opening of the buds. Buds enter the first phase directly after termination of vegetative growth, but buds of different varieties cease growth at different times. Substantially, this phase is the fundamental phase of dormancy; its duration determines the depth of winter dormancy of various plants. The characteristic of this phase of dormancy consists in the fact that the buds do not open even if the optimal conditions for their development are supplied. In the second phase of dormancy, the buds do not possess this characteristic.

Our aim was to study the duration of the autumn-winter dormancy of buds of almond, funduk, and walnut, to establish the relationship of depth of dormancy to time of flowering, and to find out the effect of thaws on the state of frost-resistance of buds.

MATERIALS AND EXPERIMENTAL METHODS

Two varieties of walnut, four varieties of funduk, and 20 varieties of almond were taken for the experiment. The walnut varieties were local, while those of funduk and almond were both local and introduced. Every year from 1953 to 1956, branches 30-40 cm long, with leaf and fruit buds, were taken from the experimental trees of each variety at regular time intervals from October through March. The first sample of branches was taken in the beginning of the second third of October, while the last sample was taken just before flowering. Walnut branches were taken from fully grown trees, while the almond and funduk branches were taken from young trees, which had only recently entered the fruit-bearing phase. The cut branches, separated by varieties, were immediately placed in water and were held in the light laboratory, at an air temperature varying from 17 to 23° C. The water in the vessels was changed periodically and the stems were cut from time to time. Observations were made after placing the branches in water, and the time of breaking dormancy and of opening of the leaf and flower buds were noted.

Time of buds' readiness for opening. According to the data of Petrov [6], those varieties and species whose buds opened within a month after they were placed in water were provisionally considered as ready for opening. Our observations on bud opening are summarized in Table 1.

From Table 1, it can be seen that funduk buds taken on September 15th did not open at all. On the second sample (October 15) the branches also gave no evidence of bud opening after standing in water for a month. Only in the almond variety Nikitskii uroshainii was the breaking of dormancy of several leaf buds noted on January 31. On the branches taken November 15, the breaking of dormancy of the leaf buds and of some of the flower buds was observed in many varieties. In addition, noticeable growth was also observed in male flowers ("catkins") of several varieties of funduk.

TABLE 1

Changes of Buds Within a Month of Standing in Water as Related to the Time the Branches Were Cut

Data of branch cutting	Almond		Funduk			Walnut		
	flower buds	leaf buds	male flowers (catkins)	Stigma of female flowers	leaf buds	male fowers (catkins)	Stigma of female flowers	leaf buds
Sept. 15	–	–	Unchanged	Did not appear	Unchanged	–	–	–
Oct. 15	Unchanged	Unchanged	Unchanged	Did not appear	Unchanged	Un-changed	Did not appear	Unchanged
Nov. 15	Dormancy broken in buds of some varieties	Dormancy broken in buds of some varieties	In some varieties elongated, but not shedding	The same	The same	The same	The same	The same
Dec. 15	In some varieties the flowers opened completetly	In most varieties the buds fully opened	Shedding in most varieties	Appeared, but not in all varieties	Opened in many varieties	The same	The same	The same
Dec. 30	The same	In almost all varieties buds fully opened	Shedding in all varieties	The same	Opened in all varieties	The same	The same	The same
Jan. 15	The same	The same	The same	Appeared in all varieties	The same	Shedding	The same	Individual buds opened
Jan. 31	In most varieties flowers fully opened	In all varieties buds fully opened	The same	The same	The same	The same	Appeared	Most buds opened
Feb. 10	The same	The same	The same	The same	The same	The same	The same	All buds opened
Feb. 20	In all varieties flowers fully opened	In all varieties buds fully opened	–	–	–	The same	Appeared	All buds opened
March 1	Opened in 2-4 days	Opened in 1-2 days	–	–	–	–	–	–

The data of Table 1 indicates that almond buds taken in the second half of December and in January were the first to open. Here, no great difference was observed between local, Crimean, European and Californian varieties. Within any given variety, the leaf buds were the first to open, followed by the flower buds, unless both types opened simultaneously. Evidently, this is explained by the fact that the period of the first phase of

TABLE 2

Change of the Flower Buds of Almond During the Month of Standing in Water at Various Parts of the Dormancy Period Depending on the Time of Sampling

Date of branch sampling	Rims		YXZ		Nikitskii pozdnotsvetushchii		Vokhchaberdi-5	
	control	current year's growth pruned by 1/3	control	current year's growth pruned by 1/3	control	current year's growth pruned by 1/3	control	current year's growth pruned by 1/3
Oct. 15	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Nov. 15	The same	The same	The same	The same	The same	The same	The same	The same
Dec. 15	The same	The same	The same	The same	The same	The same	Breaking of bud dormancy	The same
Dec. 30	Individual buds opened	Unchanged	Individual buds opened	Unchanged	Some of the buds completely opened	Unchanged	Many buds completely opened	Unchanged
Jan. 15	The same	The same	The same	The same	Buds almost completely opened	The same	The same	The same
Jan. 31.	Some buds completely opened	The same	Buds completely opened	The same	The same	Some buds opened	Buds completely opened	Individual buds opened
Feb. 10	All buds fully opened	Individual buds opened	All buds fully opened	Some buds fully opened	The same	The same	The same	Almost all buds fully opened
Feb. 20	The same	Some of the buds completely opened	The same	The same	The same	Almost all buds fully opened	The same	Buds completely opened
March 1	The same	Buds completely opened	The same	Buds completely opened	The same	Buds completely opened	The same	The same
March 10	The same	The same	The same	The same	The same	The same	The same	The same

winter dormancy is longer in flower buds than in leaf buds. In branches taken during the later time intervals, the flower and leaf buds opened simultaneously, or, as under natural conditions, the flower buds opened first, and the leaf buds opened afterwards.

Funduk buds were also ready for opening approximately in the second half of December. In funduk, the sequence of bud opening, at all sampling periods, completely corresponded to that of bud opening under natural conditions. Thus, at first the catkins shed pollen, then stigmas appeared, and then the leaf buds opened.

Walnut buds were the last to be ready for opening: they opened only on the branches taken in the second

half of January. Consequently, the period of first phase of winter dormancy was terminated in walnut approximately in the third decade of January.

Simultaneously, it was of interest to find out the effect of summer pruning on the duration of the dormancy period. For this, in addition to the usual spring pruning of one-year-old shoots, shoots of the current year's growth were pruned by one-third in the summer, i.e. the whole tip was removed, up to the well-developed buds of the middle part. The aim of this was to induce development of the lateral branches and formation of buds on those at a later time. The experiment was carried out on the almond varieties Rims, YXZ, Nikitskii pozdnotsvetushchii, and Vokhchaberdi-5. The summer pruning of green shoots was carried out in three periods. The most positive results were obtained with summer pruning carried out prior to termination of the first growth wave. When pruned at this time, all four varieties developed lateral branches, and formed normally developed flower buds on them. The difference consistsed in the fact that in the variety Nikitiskii pozdnotsvetushchii, and particularly in YXZ, the lateral branches were evenly distributed along the whole length of the shoot, while in Vokhchaberdi-5 and Rims, they formed mainly from the upper buds. Samples were cut from these lateral branches and placed in water, at the same time as samples of one-year-old shoots, for the determination of the time buds were ready to open. The results obtained are given in Table 2.

From Table 2, it can be seen that buds of the lateral branches, taken from the pruned shoots, are ready to open considerably later, since the period of their first phase of dormancy is much longer than in the buds of the main one-year-old shoots. Summer pruning considerably increases the duration of the first phase of winter dormancy and retards the time at which flower buds are ready to open. Calculations, especially carried out, have shown that similar buds which had not terminated the first phase of dormancy did not start their growth at the time of winter thaws. Because of that, they were not injured by frosts which occurred after the thaws. Thus, the percentage of styles injured after the thaws was as high as 29% in the buds of the main shoots (Vokhchaberdi-20), while in the buds of secondary shoots it was 2-3% on the average, and did not exceed 5%.

Speed of Reaction of Buds to Favorable Conditions

The degree of bud injury after winter thaws is dependent on the speed with which buds react to a short-time temperature rise. In all varieties the breaking of dormancy was just as rapid in leaf as in flower buds. The closer it was to spring, the higher the activity, and breaking of bud dormancy began at once after branches were placed in water. Dormancy was broken particularly rapidly in buds and flower buds of almond. Breaking of dormancy was very slow in walnut; buds of funduk occupied an intermediate position.

Almond varieties different in the nature of breaking of dormancy in flower buds. In the local varieties of almond, as well as in some Crimean varieties, the opening of flowers took place soon after breaking of flower bud dormancy, while in many introduced thermophillic varieties, a long interval occurred between these two phenomena, sometimes as long as 2-3 months. Here, the lower the room temperature, the longer the interval was, and vice-versa. This is explained by a biological peculiarity of the variety, in particular, its requirement for a heat sum [7]. Observations have shown that the flowering of almond varieties takes place when a heat sum of 45-162° (above a biological zero of 5°) has been reached. The majority of local varieties, and some Crimean varieties, flower at a heat sum of 51 to 67° on the average, while more thermophillic European and Californian varieties flower at a heat sum of 132-162°. As a result, flower opening in the former varieties occurs soon after breaking of dormancy in the buds, while in the latter, it does not take place soon; this has an important practical significance in connection with resitance of the buds to short-time winter thaws.

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INTRODUCTION OF PUBLISHED WORKS INTO AGRICULTURE

EFFECT OF A COMPLEX OF NUTRITIONAL FACTORS ON GROWTH, DEVELOPMENT AND PRODUCTIVITY OF TOMATOES IN GREENHOUSES

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With correct organization of greenhouse management, it is possible to provide the population with fresh vegetables throughout the whole year. In connection with this, it is necessary that the existing greenhouses should be used as efficiently and as profitably as possible. The profitableness of a greenhouse depends to a great degree on the introduction of new, more progressive methods, ensuring the production of a maximally high and stable yield.

Investigations which we carried out in 1955 under the conditions of a greenhouse of the Sakhalin Complex Scientific Research Institute [1] have shown that one may drastically change formative processes and increase productivity in tomatoes through the action of a definite system of factors on the growth and development of the tomato plants. Thus, applying additional light to tomato seedlings in the beginning of development, spraying flowers with the growth stimulator TU during flowering, and supplying intensive carbon dioxide nutrition during the fruit-bearing phase (CO_2 content in air 0.2-0.3%), we have obtained acceleration of plant development by 24 days, increase in the average fruit weight of 50%, and increase in yield of 70% over that of control plants. In addition, with this system of plant nutrition, the nutritional value of the tomatoes was increased. In the fruits, there was an increase in sugar of 1.04%, and in vitamin C of 3.2 mg per 100 g of fresh fruit weight, as compared with the fruits of control plants.

In the 1955 experiments, the soil nutrition did not enter into the complex of plant treatment. In this connection, in 1956 the effect of soil nutrition on growth, development and productivity of tomato plants was studied at the same time. Of the mineral substances important for plant nutrition, the nittogenous and carbon fertilizers were used.

EXPERIMENTAL CONDITIONS AND METHODS

The tomato variety Teplichnii VIR was used for the investigation. Seeds were planted on December 26, 1955. Before planting, seeds were soaked in a 1% solution of $KMnO_4$. Sprouts were noted on January 2, 1956. Seedlings were thinned out on January 16, at the time of appearance of two true leaves. The seedlings were transplanted into benches on February 25-26, in the beginning of flower bud formation, according to the following plan: 1) control without additional treatment; 2) nitrogen feeding (2-fold level of nitrogen 2N); 3) nitrogen feeding (2N) + carbon dioxide; 4) nitrogen nutrition (2N) + carbon dioxide + carbonate + spraying flowers with the growth stimulator TU (sodium salt of 2,4,5-trichlorophenoxyacetic acid). Experiments were carried out in six replicates. Two-stemmed plants were grown, and 10 inflorescences were left on each plant. All observations were carried out on every plant individually. The experimental results are the average of data obtained from six plants.

Nitrogen feeding, as ammonium nitrate or ammonium carbonate, was introduced into the soil, in a hole, prior to planting. When carbonate was not used, 5.7 g of ammonium nitrate per plant was introduced, while when carbonate was also used, the plants received 3.4 g of ammonium carbonate and 2.6 g of ammonium nitrate. In addition, 20 g of ammonium nitrate per plant was used for supplementary feeding during the vegetative period in plants which were not given carbonate, while 10 g of ammonium nitrate and 8 g of ammonium carbonate were

given per plant in those treatments where both nitrogen and carbonate were used.

Plant nutrition with an increase concentration of carbon dioxide was given from the beginning of the fruit-bearing phase until harvesting. During this period, 23 supplementary feedings with carbon dioxide were given. The gas treatment was carried out for 2 or 3 days during the morning hours (from 9 to 11 AM). Thirty-four and one-half kilograms of carbon dioxide were used in the course of the vegetative period.

In the beginning of the period of flowering, treatment of flowers with the growth stimulator TU was systematically carried out by the method recommended by Rakitin and Krilov [2-3]. The observations on growth and development of plants were carried out, and plant height was measured, every 10 days. The yield record was made as fruits ripened. In addition to the total yield, the structure of the yield was determined. The fresh and dry weight of vegetative organs was determined in the plants. In mature fruits, the total sugar content, vitamin C and total acidity was determined in expressed juice. The sugar determination was carried out by the method of Bertran, the amount of ascorbic acid, by the method of Til'mans, and the total acidity of the juice sample was determined by the method described by Ermakov et al. [4].

EXPERIMENTAL RESULTS

The experimental results have shown that the application of a nutritional complex is a treatment factor effective on the processes of growth and development of plants. Comparison of data characterizing the growth of vegetative and reproductive plant organs (Table 1) shows that the weight of vegetative plants is decreased in experimental plants, while the number of fruits is, on the contrary, increased. In addition, the plants were not injured by the toxic action of ammonium.

TABLE 1

Growth of Tomato Plants as Affected by the Nutritional Complex*

Experimental treatment	Plant height, in cm	Number per plant			Number of fruits, per inflorescence	Fresh weight of plants, in g	Dry weight of plants, in g
		Leaves	Inflorescences	Fruits			
Control	199.0	31.0	8.6	30.0	3.4	1940	191
Nitrogen feeding (2N)	192.0	29.0	9.3	35.3	3.8	1660	182
Nitrogen feeding (2N) + carbon dioxide	195.0	33.0	9.6	52.3	5.4	1450	163
Nitrogen feeding (2N) + carbon dioxide + carbonate + spraying with growth stimulator TU	187.0	28.3	9.0	55.0	6.1	1130	139

*In this and following tables the data given are the average of six plants.

Thus, when plants were supplied with two forms of nitrogen, the weight of the vegetative organs decreased by 280 g as compared with the control, the height decreased by 7 cm, but the number of fruits was increased by 5.3. In plants given nitrogen and carbon dioxide feeding, the weight of the vegetative organs decreased by 490 g, but the number of fruits increased by 22.3. Application of the full nutritional complex to plants decreased the fresh weight of plants by 810 g and increased the number of fruits by 25. These data show that the nitrogen feeding is more effective with a strict correlation of all elements of the nutritional complex.

The positive action of the nutritional complex applied in these experiments had an even greater effect on the rate of development of tomatoes (Table 2).

From the data of Table 2, it can be seen that the increase in the level of nitrogen nutrition insignificantly retards development of tomatoes. In plants grown with application of the complete complex of nutritional factors, the maturation of tomato fruits was speeded up by 7 days.

TABLE 2

Development of Tomatoes as Affected by the Nutritional Complex

Experimental treatment	Time (in days) from sprouting to the beginning of separated phases in plant development			
	flower bud formation	flowering	fruit initiation	harvest of fruits
Control	62	78	88	150
Nitrogen feeding (2N)	63	81	93	153
Nitrogen feeding (2N) + carbon dioxide	63	80	93	151
Nitrogen feeding (2N) + carbon dioxide + + carbonate + spraying with stimulator TU	62	81	88	143

TABLE 3

Productivity of Tomatoes as Affected by the Nutritional Complex

Experimental treatment	Fruit yield			Number per m^2		Percentage of fruit set
	per plant, in g	per m^2	in % of control	flowers	fruits	
Control	2313	13880	100	652	180	27.6
Nitrogen feeding (2N)	2340	14040	101	738	212	28.7
Nitrogen feeding (2N) + carbon dioxide	3681	22090	162	523	314	60.0
Nitrogen feeding (2N) + carbon dioxide + + carbonate + spraying with stimulator TU	5235	31440	226	527	330	63.0

TABLE 4

Structure of Tomato Yield

Experimental treatment	Number of mature fruits	Weight of fruits, in percent of total weight			Average weight, per fruit	
		more than 100 g	from 50 to 100 g	less than 50 g	in g	in %
Control	180	27.2	40.5	32.3	77.1	100
Nitrogen feeding (2N)	212	17.4	42.4	40.2	65.3	84.7
Nitrogen feeding (2N) + carbon dioxide	314	14.3	42.3	43.4	70.3	91.1
Nitrogen feeding (2N) + carbon dioxide + carbonate + spraying with stimulator TU	330	36.7	32.2	31.1	91.2	118.2

Thus, the use of a high level of nitrogen feeding, together with treatment by carbon dioxide of the air and carbon from the soil, along with spraying by growth stimulator TU, are the best conditions for development of the tomato plant.

The nitrogen condition, in combination with the other important factors, sharply changed the productivity of tomatoes (Table 3).

The data given in Table 3 show that the double level of nitrogen, without use of other treatments, causes an increase in fruit yield of only 1%. However, when the high level of nitrogen is used with simultaneous additional feeding with carbon dioxide, the yield increases by 62%, and 60% more fruit is formed, as compared to control plants. Application of all treatment factors gave a sharp increase in yield.

The positive effect of this complex is also shown on the structure of the tomato fruit yield (Table 4).

From the structure of the fruit yield, it can be seen that the number of fruits is somewhat lower, and the average weight of fruit is decreased in plants which have received 2N of nitrogen and 2N nitrogen + carbon dioxide, while with the full complement of nutritional factors, the percentage of large fruits is 35.79%, as against 27.2% for the control, and the average weight of fruits is increased up to 91.2 g, instead of 77.1 g. Consequently, the complement feeding considerably improves the commercial quality of production.

The results of the investigation concerning the formation of sugars, ascorbic acid, and total acidity (Table 5) are characteristic of those biochemical changes which were observed during complement treatment of plants by the nutritional factors studied.

TABLE 5

Content of Sugars, Ascorbic Acid and Acidity of Fresh Tomato Fruits From the First and Fifth Inflorescences of Plants

Experimental treatment	Sugar content in fresh fruits, in %		Ascorbic acid content, in mg per 100 g of fresh fruit		Acidity, calculated as maleic acid, in % (first inflorescence)
	first	fifth	first	fifth	
Control	4.34	4.58	16.03	23.86	0.48
Nitrogen feeding (2N)	5.24	5.11	11.11	21.68	0.46
Nitrogen feeding (2N) + carbon dioxide	4.97	6.26	15.87	17.89	0.43
Nitrogen feeding (2N) + carbon dioxide + carbonate + spraying with stimulator TU	5.24	5.24	19.52	22.72	0.24

NOTE: Determinations of total sugar and ascorbic acid were carried out two times on two whorls of inflorescences, while total acidity was determined only in the fruits of the first inflorescence.

On the basis of the data of Table 5, one may conclude that nitrogen nutrition together with carbon dioxide stimulates sugar accumulation and retards the formation of ascorbic acid in tomatoes. With the full complement of nutritional factors, carbon dioxide treatment leads to production of a large amount of sugar and ascorbic acid, together with a simultaneous decrease in total acidity in fruits.

SUMMARY

A study of the effect of a number of factors (supply of nitrogen and carbonate in the soil and carbon dioxide in the air) on plants whose flowers were treated with a growth stimulator (TU) showed that growth and development of the plants proceeds normally without any symptoms of ammonium poisoning. Improvement of only nitrogen nutrition somewhat retarded development of the tomatoes and did not lead to an increase of the crop yield.

Under favorable agricultural conditions in the hothouse enhanced nitrogen supply and application of high concentrations of carbon dioxide (0.2-0.3%) considerably increased the yield of tomatoes. Simultaneous supply of the plants with nitrogen and carbonate (in the form of ammonium carbonate) absorbed from the soil and of carbon dioxide absorbed from the air and spraying of the flowers with the growth stimulator TU induced a sharp decrease of the vegatative mass and an increase of the crop yield. The ascorbic acid content in this case was found to increase and the acidity to decrease.

Simultaneous supply of the nutritive substances to tomato plants changes the metabolism with subsequent

activation of growth processes of the productive organs, this being the cause of acceleration of development of the plants.

Nitrogen nutrition in conjunction with other nuritive factors is a powerful means of controlling formative processes in tomato plants.

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METHODS

A PHOTOELECTRIC METHOD FOR DETERMINING THE OPTICAL PROPERTIES OF PLANT LEAVES

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K. A. Timiriazev has written that "... if the chief function of the plant organism depends on light, then clearly the chief characteristic of plants must be sought in its optical properties" [1]. Until recently, however, the problem of the study of optical properties remained poorly developed, since the complexity and inhomogeneity of leaf structure creates certain methodological difficulties. Of special interest are the optical properties of leaves within the physiological region of the spectrum.

The optical properties of a leaf are reflection, transmission, and absorption of radiant energy, absorption being the most important, since all physiological processes are accomplished with absorbed energy.

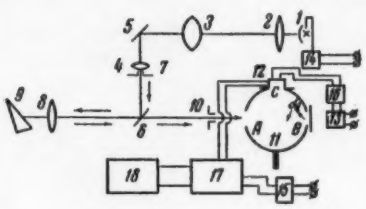

Fig. 1. Schematic diagram of apparatus: 1) light source; 2-4) condensers; 5-6) rotating mirrors; 7) entrace slit; 8) objective; 9) prism; 10) exit slit; 11) integrating sphere; 12) light detector (photomultiplier); 13-15) voltage regulators; 16) rectifier; 17) amplifier; 18) galvanometer; A) entrance aperture; B) exit aperture; C) aperture for phototube; d) screening plate.

Ordinarily, absorption (A) is determined from the equation: $100 = A + T + R$, where the radiant energy striking the leaf is taken as 100, and T and R represent the amount of that energy transmitted and reflected by the leaf. Studies of the optical properties of plant leaves have been carried out by a number of investigators [2-9]; some used filters [2], others used monochromators [3]. The main shortcoming of these investigations of the optical properties of plant leaves is the absence of an account of scattering of radiant energy by leaf tissues, which are an optically turbid medium. The exceptions are the papers of Rabideau, French, and Holt [3] and of Moss and Loomis [9], in which the integrating sphere of Ulbricht was used, but reflection and transmission were not considered separately. In the work of Il'ina [4] reflection and transmission, as well as absorption, were studied separately, but with different experimental arrangements for reflection and for transmission, which renders the investigations more difficult and allows only leaf slices to be used.

In the studies of Dadykin and Stanko [5], who used the method of comparative spectrophotometry [6], there was likewise no account of the scattering of radiant energy by the leaf. Moreover, this method, in spite of its convenience for use under field conditions, requires subsequent long and laborious photometric processing of the material. A method suggested by Sokolova [7], based on calculation of a scattering index for radiant energy and giving correct results, is also extremely tedious.

The only correct methods will be those based on the use of the integrating sphere to obtain both the reflection and the transmission of radiant energy by the leaf, because the sphere gives the total reflection and transmission independently of the structure and surface of the leaf.

The use of the integrating sphere underlies the method described in the present work; this makes it possible to work with the undamaged, intact leaf directly on the plant, and to measure radiation of very low intensity.

The overall plan of the apparatus is shown in Fig. 1.

As a source of radiant energy, a point incandescent lamp (1) (12 volts, 100 watts) is used, giving a concentrated beam of parallel light rays. This source makes it possible to obtain radiation in the range 400-800 mμ.

Light from the lamp is directed to the entrance slit of the monochromator (6) through a system of condensers (2, 3, and 4), and a rotating mirror (5); then it is reflected by a mirror (7) to the objective (8) and the dispersing prism (9), after which it leaves throught the exit slit (10) in the form of a narrow beam of monochromatic light. The monochromator was made from a KSA-1 quartz-glass spectrograph [10].

In the visible region of the spectrum the instrument has a high dispersion, which permits one to obtain a beam of light that is monochromatic within 3-5 mμ; setting it for a particular region of the spectrum is accomplished by turning a cylinder, which is connected with the prism and the objective. In the magazine section of the apparatus, in place of the sliding magazine cover, a metal plate is inserted having a window, 5 mm in diameter, that serves as the exit slit. The position of the slit is determined from the well-known lines in the spectrum of a mercury lamp (IGAR-2) and from the corresponding wavelength markings on the rotating cylinder.

The integrating sphere (11), made of metal, follows the monochromator. The sphere consists of a hollow ball made of two hemispheres, 100 mm in diameter, with three apertures: aperture A is for the incoming light beam; B is for the beam leaving the sphere, and C is for the phototube. The area of the apertures is chosen so that it makes up 1.6% of the area of the internal surface of the sphere, and satisfies the conditions for constructing an integrating sphere [12]. The diameters of the apertures A and B are each equal to 18 mm. Inside, the sphere is coated with barium oxide having a surface deposit of magnesium oxide, MgO. In the visible, near ultraviolet, and near infrared regions of the spectrum, magnesium oxide is the best reflector (R = 0.96 – 0.98) and is nonselective for different wavelength regions [11, 12].

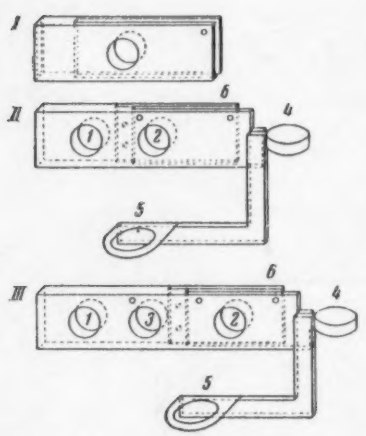

Fig. 2. Attachments to the integrating sphere:
I) chamber for slide; II) slide for a aperture A; III) slide for aperture B; 1-2) transparent apertures; 3) reflector; 4) handle of slide; 5) support for small glass; 6) spring for leaf.

The sphere makes it possible to obtain the total reflection and total transmission of light by leaves. In the presence of a standard reflector, covering aperture B, all the light scattered in the sphere strikes the phototube, comprising 100% of the incident radiant energy.

When a leaf is placed in aperture A, the transmission of light by the leaf is obtained; when the reflector is replaced by a leaf in aperture B, we obtain the reflection in the given region of the spectrum. In the sphere there is a plate d, which serves as an obstruction to the reflected light beam from the leaf in aperture B to C.

The sphere is provided with several attachements (Fig. 2). At apertures A and B are placed chambers with apertures (D = 20 mm) (Fig. 2, I), in which slides (Fig. 2, II and III) move relatively to the apertures. In slide II for chamber A there are two transparent apertures: (1) is for transmission of light directly into the sphere, and (2) is for transmission of light through the leaf, which is held in the slide with the help of a laminar spring (6). The protruding edges of the leaf go into the lengthwise slots in the chamber. The presence of a catch in the slide helps fix the slide in a definite position with respect to the apertures in the chamber and the sphere.

A similar slide III (Fig. 2) is at aperture B. Aperture (1) is for direct passage of the monochromatic light beam through the sphere and chambers containing the slides when the instrument is being set at zero; the leaf is placed in apertures (2), and held there by a spring. Depression (3) is designed to hold a standard reflector (MgO). Omission of the special base layer in aperture (2) used by other authors allows us to obtain the true reflection of radiant energy by the leaf. The plant's root system, or the leaf stalk, is placed in a small glass containing water or some solution, and moves with the slide; the glass is held by a special receptacle on the slide (5) (Fig. 2).

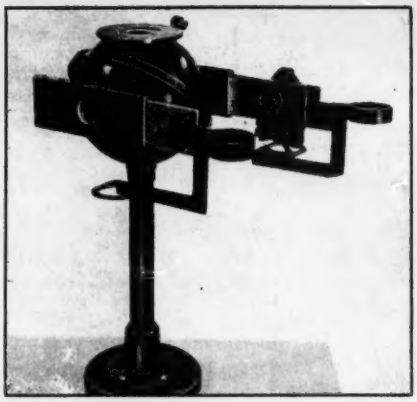

Fig. 3. Overall view of integrating sphere.

An overall view of the sphere is shown in Fig. 3.

The exit slit of the monochromator and the sphere with its photodetector are placed in a dark chamber (made of black paper impermeable to light) to remove outside light, which introduces errors in the photodetector readings. A type FEU-22 photomultiplier is used as a detector of radiant energy (Fig. 1, 12). Its spectral sensitivity (Fig. 4) covers the entire visible region of the spectrum [13].

Line current, fed to a type VSE-2500 rectifier (Fig. 1, 16) and passing through an STN-250 ferroresonance regulator (Fig. 1, 13), is used as a power source for the photomultiplier. The normal voltage on the photomultiplier is 1300 volts, or 100 volts per stage. The dark current does not exceed 10^{-8} to 10^{-7} amperes. In operation, the photomultiplier has quite good stability and low fatigue.

To increase the sensitivity of the instrument and the possiblity of detecting weak light intensities, the photomultiplier is coupled to a constant-current amplifier* (Fig. 1, 17), which works on the principle of the balancing network [14].

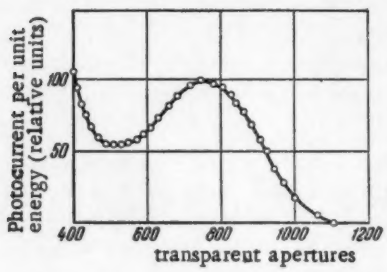

Fig. 4. Spectral sensitivity curve of FEU-22.

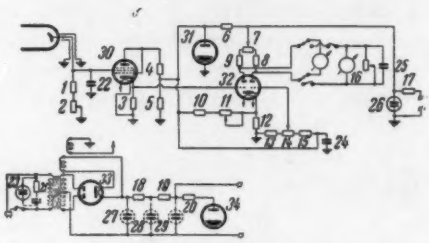

Fig. 5. Schematic diagram of constant-current amplifier.

TABLE

Amplifier Parts List

Part No.	Item	Size	Part No.	Item	Size
1	Resistor	1 MΩ	18	Resistor	500 Ω
2	"	10 MΩ	19	"	2000 Ω
3	"	300 kΩ	20	"	2× 800 Ω
4	"	200 kΩ	21	"	33 k Ω
5	"	35 kΩ	22	Condenser	100 pF 500 v
6	"	50 kΩ	23	"	50 000 pF 500 v
7	"	150 kΩ	24	"	10×450
8	"	100 kΩ	25	"	1 mF 500 v
9	"	100 kΩ	26	"	10×450
10	"	0,5 MΩ	27	"	40 mF 450 v
11	"	1.5 MΩ	28	"	10 mF 450 v
12	"	800 Ω	29	"	10 mF 450 v
13	"	100 kΩ	30	Tube	6Zh7
14	"	1,5 MΩ	31	"	SG-4S (VR-150)
15	"	1 MΩ	32	"	6N7-S
16	"	3,6 kΩ	33	"	5UCh (5Ts3S)
17	"	5000 Ω	34	"	SG-1P

*The constant-current amplifier was developed by our colleague in the Institute of Plant Physiology, V. P. Kornil'ev, and we wish to express our thanks to him.

A schematic diagram of the amplifier is shown in Fig. 5, and data on the tubes and parts are given in the table.

A test of the linearity of the amplifier and photomultiplier, with the use of a set of neutral filters on the sphere, showed that at minimum and maximum amplifications, the linearity is held within ±2%.

The amplifier was combined with a type M-91 100-microampere shadow-indicator microammeter, having 100 divisions, calibrated to read full scale with the standard reflector in position. A condenser (500 microfarad) is connected across the terminals of the galvanometer, to improve the stability of the instrument. Fluctuations in the apparatus amount to ± 1-1.5 microampers, which corresponds to an error of ±1-1.5%.

Prior to the beginning of operation, the amplifier and the photomultiplier are allowed to warm up for 10-15 minutes, after which the monochromator is set for a particular wavelength, and the light rays enter the sphere, aperature B which is covered by the reflector of slide III (Fig. 2). A voltage corresponding to approximately 100 divisions on the galvanometer is applied to the photomultiplier. Then the reflector is removed, and the light passes straight through the sphere, whereupon the photomultiplier dark current is balanced, and the galvanometer pointer is set at zero by adjusting the potentiometer. With a second determination of the total reflection from sphere and reflector, the pointer is set exactly at the "100" mark of the galvanometer, which is accomplished by changing the resistance (shunt) of the galvanometer itself. To provide stable operation of the instruments, a type STN-250 voltage regulator (Fig. 1) is used and the amplifier itself is screened.

By moving slides II and III (Fig. 2) in relation to apertures A and B, we obtain the reflection and transmission by the leaf, from which the absorption of radiant energy by the leaf is then calculated. Similar operations are carried out at other wavelengths. Determination of absorption of radiant energy by the leaf between 400 and 800 mμ takes 0.5-1.0 hour, and does not require supplementary processing of the data.

Figure 6 shows the curves of reflection, transmission, and absorption of radiant energy by the leaf of the bean (Phaseolus vulgaris).

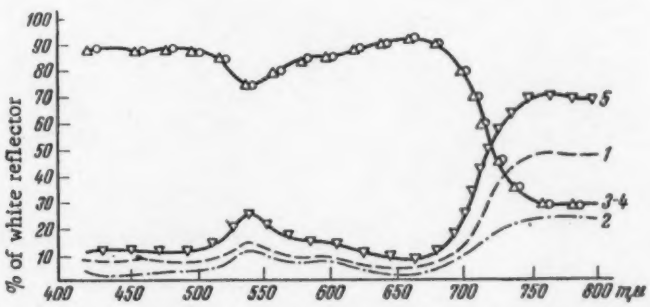

Fig. 6. Reflection, transmission, and absorption spectra for bean leaves (Phaseolus vulgaris):
1) reflection; 2) transmission; 3-4) absorption (3 – plant leaf with root system in soil; 4 – plant leaf without root system, in water); 5) reflection + transmission.

The absorption of radiant energy is maximal in the blue (89%) and red (90%) rays and minimal in the green (65%). Moreover, absorption of approximately 30% is observed in the near infrared region. Absorption is the same in the leaves of plants with root systems in the soil (Fig. 6, curve 3) and of plants without root systems with their stems submerged in water for various numbers of hours (curve 4). This shows the possiblity of studying plant leaves without root systems.

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* In Russian.

CURRENT EVENTS

CONFERENCE ON PHYSIOLOGY AND ECOLOGY OF PLANT GROWTH

Iu. V. Rakitin

An extensive conference on physiology and ecology of plant growth was held in Lvov, from June 2 to 10, 1958. This conference, organized by the Ivan Franko Lvov State University and the Lvov branch of the Ukrainian Botanical Society, attracted the wide attention of Soviet physiologists. Nearly 300 scientists participated in this conference, representing institutes of plant physiology, biophysics, and central botanical garden, the botanical institute and affiliated branches of the USSR Academy of Sciences, institutions of the republican VASKhNIL Academy of Sciences, the Ukrainian, Belorussian and Georgian academies of agricultural sciences, the Moscow, Leningrad, Kiev, Lvov, Kazan, Voronezh, Tiflis, Tartus, Odessa, Chernovits, Uzhgorod and other universities, a number of agricultural and instructional institutes, and agricultural experiment stations.

The conference work was conducted in plenary and sectional meetings. The following ten sections functioned at the conference (the leaders of sections are given in parenthesis): 1) physiology of fruit, seed, and root growth (F. L. Kalinin and A. A. Prokofev); 2) growth and soil conditions (S. M. Mashtakov and E. I. Ratner); 3) relationship of polarity and dormancy (G. Kh. Molotkovskii and L. I. Sergeev); 4) ecology (A. S. Lazarenko, A. G. Tavadze, V. V. Sakharov, M. Kh. Chailakhian and A. F. Kleshnin); 5) vegetative reproduction and regeneration (L. I. Dzhaparidze and L. F. Pravdin); 6) morphogenesis (V. G. Aleksandrov and F. M. Kuperman); 7) auxins and herbicides (Iu. V. Rakitin and N. A.Liubinskii); 8) growth and penetrating radiation (L. P. Breslavets and P. A. Vlasiuk); 9) vitamins and growth (I. K. Dagis and K. E. Ovcharov); 10) individual applied problems of growth physiology (S. I. Lebedev and N. S. Turkova).

The conference opened with an introductory speech by the head of Lvov University, Professor E. K. Lazarenko. At the plenary sessions reports were presented by Professor S. O. Grebinsky (Lvov) on "The Contemporary Sate of Plant Growth Physiology," by Professor Iu. V. Rakitin (Moscow) on "Plant Stimulation and Phytohormones," and by Candidate of Biological Sciences N.A. Luibinskii (Kiev) on "Physiology of Vegetative Reproduction in the Light of Contemporary Data," by Prof. M. Kh. Chailakhian (Moscow) on "Gibberellins as Factors in the Growth and Flowering of Plants," by Prof. P. A. Genkel'(Moscow) on "Plant Physiology in China," and by Candidate of Biological Sciences R. G. Butenko (Moscow) on "Cultivation of Isolated Tissues as a Method of Studying Plant Growth and Morphogenesis." At the plenary and sectional meetings of the Lvov conference 103 reports were read and discussed.

As is evident from the anmes of the above-mentioned sections, many problems of the physiology and ecology of plant growth were discussed.

Work of the section on "Physiology of Fruit, Seed and Root Growth" was devoted to solving such problems as embryonic plant development (F. L. Kalinin (Kiev)) , properties and formation conditions of fruits and seeds of fatty plants (A. A. Prokofev (Moscow), E. V. Pontavich (Moscow), I. G. Vyvalko (Kiev)), histochemical investigations of seed germination (V. A. Poddubnaia-Arnol'di(Moscow)); growth physiology of root system (N. G. Potapov, N. V. Obrucheva and M. Maroti (Moscow)).

In the section on "Growth and Soil Conditions," problems of nutrition, growth and development of plants on mineral and peat soils were discussed (S.M. Mashtakov (Minsk), A. S. Palamarchuk (Lvov)), effect of molybdenum microdoses on growth, development and intraspecies relations in phytocenoses of perennial grasses (E. I. Ratner (Moscow)), phosphorus nutrition of woody plants at an early stage (S. I. Slukhai (Kharkov)), fertility increase of grape vines by improving its nutritive regimen (E. K. Plakida (Odessa)), the anatomical-morphological

structure of stalks of winter wheat in relation to nutrive conditions (A. D. Khomchenko and M. Iu. Nichiporchuk (Lvov)).

The participants showed broad interest in the work of the section on "Correlation, Polarity and Dormancy," where papers were read on manifestations of polarity in relation to physiological processes and plant structure (G. Kh. Molotkovskii (Chernovits)), distribution of biochemical processes (T. A. Kezeli (Tiflis)) and bioelectric potentials in plant body (G. L. Kliachko-Gurevich (Moscow)), on morphologo-physiological properties of the annual cycle in development of woody varieties (L. I. Sergeev and K. A. Sergeeva (Ufa)), on characteristics of life forms in the family Pyroloceae Lind (N. V. Shilova (Leningrad)) and on physiological properties of the dormant period of some fruit cultures (E. Z. Oknina (Moscow)), on leaf gathering on tea bushes (Ali-Zade (Baku)), and the nature of secondary dormancy in seeds (M. G. Nikolaeva, L. M. Kozlova, and V. G. Iudina (Leningrad)).

The largest number of reports were delivered in the section on "Ecology." A considerable portion of them dealt with biological properties, growth and development of woody and bushy plants under different ecologic conditions (V. G. Kolishchuk (Lvov), S. M. Stoiko (Lvov), A. V. Chubatyi (Lvov), N. A. Borodina (Moscow), M. S. Dvorakovskii (Moscow), V. V. Grinenko (Stalinabad), A. V. Paravian (Alma-Ata), A. I. Smetannikova (Leningrad), A. I. Korovin (Petrozavodsk)). Several reports were devoted to clarifying the dependence of plant growth and development on means of illumination (P. G. Tavadze (Tiflis), M. A. Brukhlei (Ternopol), V. F. Koriakina (Leningrad), N. P. Voskresenskaia and T. S. Grishina (Moscow)) and conditions of photoperiodic activity (E. Ia. Ermolaeva and N. A. Kozlova (Leningrad)). In his report P. S. Belikov (Moscow) told of daily variations of the rhythm of photosynthesis in wheat ontogenesis. Much factual data relating to phenomena of growth and development of polyploid plants was given in the report of V. V. Sakharov (Moscow). Reports by A. F. Kleshnin and I. A. Shulgin (Moscow) were dedicated to an analysis of problems of energy balance of leaves on different ecotype plants. New factual data on the nature of germinating seeds of mountainous plants were stated in the report of K. A. Malinovsky (Lvov). Also the report of T. K. Zelenchuk (Lvov) on germinating seeds of wild-growing meadow grasses evoked interest. Results of a study of physiological processes and morphological structure of walnut plants in relation to their transplantation to new environments were reported by I. N. Konovalov, P. I. Lerman, E. N. Mikhaleva and N. V. Shilova (Leningrad). The report by F. F. Leisle (Leningrad) was devoted to the problems of experimental modification of plant form. L. Ia. Polozova (Moscow) reported on the relationship of growth processes and oak sexualization.

Research of the section on "Vegetative Reproduction and Regeneration" was quite extensive. Reports with interesting, abundant experimental data were read by the leaders of this section, L. I. Dzhaparidze (Tiflis) and L. F. Pravdin (Moscow). The first spoke of sex differences in the regenerative capacity of diclinous plant grafts, and the second on the possiblities of utilizing vegetative reproduction in the selection of woody varieties. New original data on the physiology of regenerative processes of grapevine grafts were presented in the report of E. A. Makarevskaia (Tiflis). Wide interest was given the report of K. E. Tskhakaia (Tiflis) devoted to the presentation of her research in the area of meristem activity by monocotyledons in relation to the nature of growth. In the reports of B. P. Florova (Minsk), A. A. Petrosian (Kishinev), Eremeeva (Yalta), and N. N. Sagaidai (Odessa), communications were read on physiologically interesting and practically feasible investigations in the field of vegetative reproduction and utilization of grafting for this purpose. R. Kh. Turetskaia (Moscow) presented an interesting report on physiological activity of growth stimulants in reproduction of plants by grafts.

The activities of the "Morphogenesis" section proceeded energetically. In reports presented here, problems were discussed on the structural genetic role of plastids in the vegetative cell (V. G. Aleksandrov (Leningrad)), mechanism of organogenesis of cultivated plants (F. M. Kuperman (Moscow)), features of organ-formation processes in the ontogenesis of leguminous plants (E. I. Rzhanova (Moscow)), development of flower buds of the apple tree and other woody varieties (I. A. Uskov (Stavropol region), A. I. Cheliadinova (Moscow)), features of flower development in the cucmber plant (I. N. Lvova (Moscow)), the mechanism of stalk and leaf growth in different corn varieties (S. A. Baranova (Moscow)). Characteristics of corn development with different lengths of daylight (D. F. Lykhvar and R. F. Beilis-Byrova (Lvov)), data on initial differentiation of top-most meristem (Z. P. Rostovtseva (Moscow)).

Considerable attention at the conference was given to the examination and practical utilization of substances with pronounced physiological activity. Three reports, mentioned above, were devoted to these problems at plenary meetings (Iu. V Rakitin (Moscow), N. A. Liubinskii (Kiev), M. Kh. Chailakhian (Moscow)), all the reports in the sections "Auxins and Herbicides" and "Vitamins and Growth," as well as several reports in other sections.

In the reports of the section "Auxins and Herbicides," problems of testing new growth stimulants were discussed (K. K. Bragina (Moscow)), the role of heteroauxin in metabolism of vegetative tissues (V. V. Polevoi (Leningrad)), chromatographic study of auxins (D. M. Grodzinskii and A. M. Grodzinskii (Kiev)), effect of stimulatory and inhibitory doses of 2,4-D on biochemical modifications in the plant (K. L. Povolotskaia and Iu. V. Rakitin (Moscow), V. M. Torchinskaia (Lvov)), the effect of inhibitors on the character of respiration in dormant plant organs (M. G. Kubli (Leningrad)), the phytohormone activity as a factor of new formations in grapes (T. K. Enin (Kishinev)), effect of stimulators on grapevine grafts (A. V. Koberidze (Tiflis)), effect of heteroauxin on physiological processes in the cotton plant (Agakishiev (Ashkhabad)), and disturbance of the dormant state by chemical action (N. A. Satarova (Moscow)).

The section on "Vitamins and Growth" was devoted to discussing reports on the establishment of the relationship between intensity of plant metabolism and their vitamin content (I. K. Dagis (Vilna), K. I. Bekaia (Tiflis), Z. I. Zaitseva (Moscow), A. A. Zemlianukhin (Voronezh)), and reports in which discussions were held on the state of avitaminosis and hypervitaminosis in plants (K. E. Ovcharov (Moscow)), and the effect of vitamins on growth and other physiological processes in plants (P. I. Bluzmanas (Vilna), L. A. Liukova (Lvov), A. G. Gelbrardt (Lvov), S. A. Belokon (Kiev), E. I. Ratner (Moscow)).

Interesting papers were presented in the section on "Growth and Penetrating Radiations." L. P. Breslavets (Moscow) reported on cell modifications and its structural components as influenced by radiation. O. N. Sorokina (Moscow) reported on the development and cytochemistry of wheat germ when irradiated by neutrons. There was a communication by V. V. Khvostova and S. A. Valev (Moscow) on plant radiosensitivity. S. O. Grebinskii, G. V. Zagorodniuk and I. V. Popovich (Lvov) reported on the results of their investigations on stimulating growth of sugar beets and vegetables by x-irradiation of seeds. The activity of the x-rays and radioactive phosphorus on the yield and quality of sugar beets and corn was reported in the communication of N. I. Tikhonov (Sumy). Finally, at this section a report was made on the effect of ionizing radiation on growth and economic productivity (Kharkov).

The attention of many conference participants was attracted also by the work of the section on "Indiviual Applied Problems of Growth Physiology." Reports were presented here on causes of cereal grain wilt (N. S. Turkova (Moscow)), and resistance to wilt in summer wheat in relation to plant development (V. N. Tsiurupa (Rostov-on-Don)); the effect of preplanting germination of tubers on the course of ontogenesis and yield of potatoes (P. I. Gupalo (Zhitomir)); on physiological growth features and development of potatoes in summer planting (S. M. Gedz (Chernovits)), on the effect of extra root nutrition by mineral fertilizers at different soil moistures on corn growth and development (N. S. Petinov and V. P. Ivanov (Moscow)), and the effect of extra root feeding of tomato seedlings on yield and quality of fruit (O. A. Grechukhina, N. V. Pomazkov and A. S. Vedneeva (Leningrad)).

At the closing (plenary) session of the conference, a resolution was accepted characterizing the contemporary state of research in physiology and ecology of plant growth and projecting basic directions of subsequent research in this field.

The conference noted that extensive scientific work is being carried on in the Soviet Union on the indicated problems. Substantially extended are researches on the study of effects of internal and external factors on plant growth and development, of studying the plant as a single unit, its inherent polarity and relationships between its different organs. More and more attention is being given to solving problems on physiology of organogenesis, sexual differentiation, sexual and vegetative reproduction, growth physiology of cells, tissues, and dormancy.

The conference affirmed the fact that Soviet physiologists carry on extended work in clarifying the physiological role and the activity mechanism of auxins, vitamins, nucleic acids, gibberellins, and other metabolites, which are characteristic of high physiological activity. The conference also noted that Soviet science has advanced considerably in the study of phenomena of stimulation, inhibition, and herbicidal action caused by chemicals and diverse physical agents. Based on results of experiments conducted, and comparing these to known data in the literature, new theoretical generalizations are arrived at, which permit a deeper comprehension of the acquired factual material and aid further research in the indicated directions. Simultaneously with the theoretical treatment of these directions, a more extensive application of chemical substances as stimulants of root formation, as speeding the growth and ripening of fruit, and a means for normalizing harvests and decreasing the preharvest fruit ripening, for delay of germination of tubers, edible root plants and bulbs when stored for a long period, and on overcoming the dormancy period, defoliation and preharvesting plant desiccation, as weed exterminators.

The materialistic concept by Soviet science of the relationship of organisms to the medium surrounding them

caused a considerable revival in ecologic studies of plant growth and development and the reciprocal effect of vegetative organisms.

As the investigations of Soviet scientists have shown, resitance of plants to low and high temperatures, to soil and atmospheric drought, to different types of soil salinity, which is of great practical significance – should be considered in close relationship to phenomena of ecologic adaptation. Deserving special attention is a study of physiological activity of such ecological factors as the duration, intensity and spectral composition of light, the temperature of the surrounding environment, and its daily and seasonal variations. Together with this object of fixed attention there should be the species behavior not only under ordinary, but under extreme conditions of existence, when frequently an intense variation occurs accompanied by an increase in chromosome numbers and a generally deep biological reorganization of vegetative organisms. In relation to this, a considerable interest is presented by phenomena of natural and artificially induced polyploidy, permitting creation of new plant forms, useful in the practice of plant culture.

The conference recognized it as necessary to further expand and widen the studies on physiology and ecology of growth and development of plants; among these such problems as theoretical bases ofplant ontogenesis and clarifying the physiological nature of its different stages, specific functions of various organs, their interrelationship, polarity and dormant state, physiology of vegetative cell and tissue growth, and the plant as a unit, the activity of root and leaf and other plant organs as related to the processes of plant interactions in cenoses, further clarification of the role of macro- and microelements, development of leaf diagnosis in plant requirements of mineral and organic fetilizers, character of plant growth and development in relation to nutritive conditions, clarification of relations and form and function as a basic problem of ecologic physiology, behavior of species under different environmental conditions, including extreme conditions of existence, the physiological role of auxins, vitamins, nucleic acid, gibberellins, and other metabolites, clarification of the role of hormonal factors in processes of growth, morphogenesis, correlative relations, transport and distribution of substances in plants, revealing the essence of physiological activity of different chemical compounds utilized as stimulants, inhibitors and herbicides, the study of changes caused by radiation.

The conference considered it essential to intensify the development of practical means of managing plant life activity and to broaden propaganda and incorporate into the national economy the accomplishment so far attained in this field.

The conference approved the intiative of Ivan Franko Lvov State University and the Lvov Affiliate of the Ukrainian Botanical Society in conducting this conference, and considered it useful to call similar conferences in other educational centers of the country, since these conferences play an important role in coordinating scientific research.

The conference decided to request the head of the Georgian University to organize a conference in Georgia in 1960 on the physiology and ecology of plants. The conference took notice of the necessity of broadening physiological studies in affiliates of the Academy of Sciences of the USSR, in the Academies of Science and scientific institutions of the republics of VASKhNIL republican academies of agricultural sciences, in branches of plant-cultivation institutes and at the experimental stations, and, in relation to this, to training suitable cadres of physiologists.

The conference noted that the number of publications on problems of physiology and ecology in plant growth and development is not proportional to the significance of the problem and the scale of work conducted in this field, and decided to request editors of botanical journals to expand information in the pages of their journals on these problems.

In order to create proper conditions for physiological studies, the conference decided to request the Ministry of Chemical Industry of the USSR and other organizations to increase the allotment and to improve the supply of research institutions with materials and reagents for chromatographic analysis and pure chemical preparations, for use as stimulants, inhibitors, and herbicides, among them compounds labeled with radioactive isotopes.

To complete the conference work, all participants undertook interesting ecologic excursions into Carpathia.

ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN RUSSIAN BIO-SCIENCES LITERATURE

Abbreviation (Transliterated)	Significance
AMN SSSR	Academy of Medical Sciences, USSR
AN SSSR	Academy of Sciences, USSR
BIN	Biological Institute, Botanical Institute
FTI	Institute of Physiotherapy
GONTI	State United Sci-Tech Press
GOST	All Union State Standard
GRRRI	State Roentgenology, Radiology, and Cancer Institute
GTTI	State Technical and Theoretical Literature Press
GU	State University
I Kh N	Scientific Research Institute of Surgical Neuropathology
IL (IIL)	Foreign Literature Press
IONKh	Inst. Gen. and Inorganic Chemistry (N. S. Kurnakov)
IP	Soil Science Inst. (Acad. Sci. USSR)
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd.	Press
LEM	Laboratory for experimental morphogenesis
LENDVI	Leningrad Inst. of Dermatology and Venereology
LEO	Laboratory of Experimental Zoology
LIKhT	Leningrad Surgical Institute for Tuberculosis and Bone and Joint Diseases
LIPZ	Leningrad Inst. for Study of Occupational Diseases
LIPK	Leningrad Blood Transfusion Institute
Medgiz	State Medical Literature Press
MOPISh	Moscow Society of Apiculture and Sericulture
MVI	Moscow Veterinary Institute
MZdrav	Ministry of Health
MZI	Moscow Zootechnical Institute
LOKhO	Leningrad Society of Orthopedic Surgeons
NIIZ	Scientific Research Institute of Zoology
NINKhI	Scientific Research Institute of Neurosurgery
NIU	Scientific Institute for Fertilizers
NIUIF	Scientific Research Institute of Fertilizers and Insecticides
NIVI	Veterinary Scientific Research Institute
ONTI	United Sci. Tech. Press
OTI	Division of Technical Information
RBO	Russian Botanical Society
ROP	Russian Society of Pathologists
SANIIRI	Central Asia Scientific Research Institute of Irrigation
SANIISh	Central Asia Scientific Research Institute of Sericulture
TsNII	All-Union Central Scientific Research Institute
TsNTL	Central Scientific and Technical Laboratory
VASKhNIL	All-Union Academy of Agricultural Sciences
VIG	All-Union Institute of Helminthology
VIEM	All-Union Institute of Experimental Medicine
VIR	All-Union Institute of Plant Cultivation
VIUAA	All-Union Institute of Fertilizers, Soil Science, and Agricultural Engineering
VIZR	All-Union Institute of Medical and Pharmaceutical Herbs
VNIRO	All-Union Scientific Institute of Fishing and Oceanography
ZIN	Zoological Inst. (Acad. Sci. USSR)

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us. - Publisher.

RUSSIAN JOURNALS FREQUENTLY CITED
[Biological Sciences]

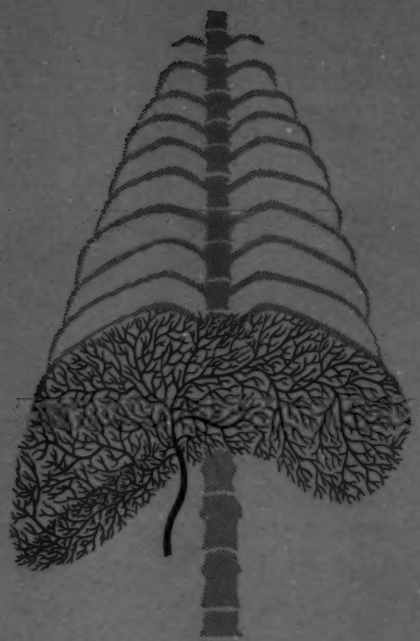
Abbreviation*	Journal*	Translation
Agrobiol.	Agrobiologiia	Agrobiology
Akusherstvo i Ginekol.	Akusherstvo i Ginekologiia	Obstetrics and Gynecology
Antibiotiki	Antibiotiki	Antibiotics
Aptechnoe Delo	Aptechnoe Delo	Pharmaceutical Transactions
Arkh. Anat. Gistol. i Embriol.	Arkhiv Anatomii Gistologii i Embriologii	Archives of Anatomy, Histology, and Embryology
Arkh. Biol. Nauk SSSR	Arkhiv Biologicheskikh Nauk SSSR	Archives of Biological Science USSR
Arkh. Patol.	Arkhiv Patologii	Archives of Pathology
Biofizika	Biofizika	Biophysics
Biokhimiia	Biokhimiia	Biochemistry
Biokhim. Plodov i Ovoshchei	Biokhimiia Plodov i Ovoshchei	Biochemistry of Fruits and Vegetables
Bot. Zhur.	Botanicheskii Zhurnal	Journal of Botany
Biull. Eksptl. Biol. i Med.	Biulleten Eksperimentalnoi Biologii i Meditsiny	Bulletin of Experimental Biology and Medicine
Biull. Moskov. Obshchestva Ispytatelei Prirody, Otdel Biol.	Biulleten Moskovskogo Obshchestva Ispytatelei Prirody, Otdel Biologicheskii	Bulletin of the Moscow Naturalists Society, Division of Biology
Doklady Akad. Nauk SSSR	Doklady Akademii Nauk SSSR	Proceedings of the Academy of Sciences USSR
Eksptl. Khirurg.	Eksperimentalnaia Khirurgiia	Experimental Surgery
Farmakol. i Toksikol.	Farmakologiia i Toksikologiia	Pharmacology and Toxicology
Farmatsiia	Farmatsiia	Pharmacy
Fiziol. Rastenii	Fiziologiia Rastenii	Plant Physiology
Fiziol. Zhur. SSSR	Fiziologicheskii Zhurnal SSSR im. I. M. Sechenova	I. M. Sechenova Physiology Journal USSR
Gigiena i Sanit.	Gigiena i Sanitariia	Hygiene and Sanitation
Izvest. Akad. Nauk SSSR, Ser. Biol.	Izvestiia Akademii Nauk SSSR, Seriia Biologicheskaia	Bulletin of the Academy of Sciences USSR, Biology Series
Izvest. Tikhookeanskogo N. I. Inst. Rybnogo Khoz. i Okeanog.	Investiia Tikhookeanskogo N. I. Instituta Rybnogo Khoziaistva i Okeanografii	Bulletin of the Pacific Ocean Scientific Institute of Fisheries and Oceanography
Khirurgiia	Khirurgiia	Surgery
Klin. Med.	Klinicheskaia Meditsina	Clinical Medicine
Lab. Delo	Laboratornoe Delo (po Voprosam Meditsiny)	Laboratory Work (on Medical Problems)
Med. Parazitol.	Meditsinskaia Parazitologiia i Parazitarnye Bolezni	Medical Parasitology and Parasitic Diseases
Med. Radiol.	Meditsinskaia Radiologiia	Medical Radiology
Med. Zhur. Ukrain.	Medichnii Zhurnal Ukrainskii	Ukrainian Medical Journal
Mikrobiologiia	Mikrobiologiia	Microbiology
Mikrobiol. Zhur.	Mikrobiologichnii Zhurnal	Microbiology Journal
Nevropatol., Psikhiat. i Psikhogig.	Nevropatologiia, Psikhiatriia i Psikhogigiena	Neuropathology, Psychiatry and Psychohygiene
Ortoped., Travmatol. i Protez.	Ortopediia, Travmatologiia i Protezirovanie	Orthopedics, Traumatology and Prosthetics
Parazitol. Sbornik	Parazitologicheskii Sbornik	Parasitology Collection
Pediatriia	Pediatriia	Pediatrics
Pochvovedenie	Pochvovedenie	Soil Science
Priroda	Priroda	Nature
Problemy Endokrinol. i Gormonoterap.	Problemy Endokrinologii i Gormonoterapii	Problems of Endocrinology and Hormone Therapy
Problemy Gematol.	Problemy Gematologii i Perelivaniia Krovi	Problems of Hematology and Blood Transfusion
Problemy Tuberk.	Problemy Tuberkuleza	Problems of Tuberculosis
Sovet. Med.	Sovetskaia Meditsina	Soviet Medicine
Sovet. Vrachebny Zhur.	Sovetskii Vrachebnyi Zhurnal	Soviet Physicians Journals
Stomatologiia	Stomatologiia	Stomatology
Terap. Arkh.	Terapevticheskii Arkhiv	Therapeutic Archives
Trudy Gelmint. Lab.	Trudy Gelmintologicheskoi Laboratorii	Transactions of the Helminthology Laboratory
Trudy Inst. Genet.	Trudy Instituta Genetiki	Transactions of the Institute of Genetics

* LIBRARY OF CONGRESS TRANSLITERATION SYSTEM.

(continued)

(continued)

Abbreviation	Journal	Translation
Trudy Inst. Gidrobiol.	Trudy Instituta Gidrobiologiia	Transactions of the Institute of Hydrobiology
Trudy Inst. Mikrobiol.	Trudy Instituta Mikrobiologiia	Transactions of the Institute of Microbiology
Trudy Inst. Okean.	Trudy Instituta Okeanologiia, Akademii Nauk SSSR	Transactions of the Institute of Oceanology, Academy of Sciences, USSR
Trudy Leningrad Obshchestva Estestvoisp.	Trudy Leningrad Obshchestva Estestvoispytatelei	Transactions of the Leningrad Society of Naturalists
Trudy Vsesoiuz. Gidrobiol. Obshchestva	Trudy Vsesoiuznogo Gidrobiologicheskogo Obshchestva	Transactions of the All-Union Hydrobiological Society
Trudy Vsesoiuz. Inst. Eksptl. Med.	Trudy Vsesoiuznogo Instituta Eksperimentalnoi Meditsiny	Transactions of the All-Union Institute of Experimental Medicine
Ukrain. Biokhim. Zhur.	Ukrainskii Biokhimichnii Zhurnal	Ukrainian Biochemical Journal
Urologiia	Urologiia	Urology
Uspekhi Biokhimiia	Uspekhi Biokhimiia	Progress in Biochemistry
Uspekhi Sovremennoi Biol.	Uspekhi Sovremennoi Biologiia	Progress in Contemporary Biology
Vestnik Akad. Med. Nauk SSSR	Vestnik Akademii Meditsinskikh Nauk SSSR	Bulletin of the Academy of Medical Science USSR
Vestnik Khirurg. im. Grekova	Vestnik Khirurgii imeni Grekova	Grekov Bulletin of Surgery
Vestnik Leningrad. Univ. Ser. Biol.	Vestnik Leningradskogo Universiteta, Seriia Biologii	Journal of the Leningrad Univ., Biology Series
Vestnik Moskov. Univ., Ser. Biol. i Pochvov.	Vestnik Moskovskogo Universiteta, Seriia Biologii i Pochvovedeniia	Bulletin of the Moscow University, Biology and Soil Science Series
Vestnik Oftalmol.	Vestnik Oftalmologii	Bulletin of Ophthalmology
Vestnik Oto-rino-laringol.	Vestnik Oto-rino-laringologiia	Bulletin of Otorhinolaryngology
Vestnik Rentgenol. i Radiol.	Vestnik Rentgenologii i Radiologii	Bulletin of Roentgenology and Radiology
Vestnik Venerol. i Dermatol.	Vestnik Venerologii i Dermatologii	Bulletin of Venereology and Dermatology
Veterinariia	Veterinariia	Veterinary Science
Vinodelie i Vinogradarstvo	Vinodelie i Vinogradarstvo SSSR	Wine-Making and Viticulture
Voprosy Klin.	Voprosy Klinicheskie	Clinical Problems
Voprosy Med. Khim.	Voprosy Meditsinskoi Khimii	Problems of Medical Chemistry
Voprosy Med. Virusol.	Voprosy Meditsinskoi Virusologii	Problems of Medical Virology
Voprosy Neirokhirurg.	Voprosy Neirokhirugii	Problems of Neurosurgery
Voprosy Onkol.	Voprosy Onkologii	Problems of Oncology
Voprosy Pitaniia	Voprosy Pitaniia	Problems of Nutrition
Voprosy Psikhologii	Voprosy Psikhologii	Problems of Psychology
Voprosy Virusologii	Voprosy Virusologii	Problems of Virology
Vrachebnoe Delo	Vrachebnoe Delo	Medical Profession
Zav. Lab.	Zavodskaia Laboratoriia	Factory Laboratory
Zhur. Mikrobiol., Epidemiol. i Immunobiol.	Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii	Journal of Microbiology, Epidemiology, and Immunobiology
Zhur. Nevropatol. i Psikhiat.	Zhurnal Nevropatologii i Psikhiatrii imeni S. S. Korsakov	S. S. Korsakov Journal of Neuropathology and Psychiatry
Zhur. Obshchei Biol.	Zhurnal Obshchei Biologiia	Journal of General Biology
Zhur. Vysshei Nerv. Deiatel.	Zhurnal Vysshei Nervnoi Deiatelnosti imeni I. P. Pavlova	I. P. Pavlov Journal of Higher Nervous Activity
Zool. Zhur.	Zoologicheskii Zhurnal	Journal of Zoology



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Origins of Angiospermous Plants. By A. L. Takhtajian. Edited by G. Ledyard Stebbins. Translated by Olga H. Gankin. 68 pgs. Ready now. $3.00 (U.S. & Canada) $3.50 (Foreign)

Essays on the Evolutionary Morphology of Plants. By A. L. Takhtajian. Edited by G. Ledyard Stebbins. Translated by Olga H. Gankin. Ready November 1958. $5.00 (U.S. & Canada) $5.50 (Foreign)

Problems in the Classification of Antagonists of Actinomycetes. By G. F. Gause. Edited by David Gottlieb. Translated by Fritz Danga. Ready early 1959. $5.00 (U.S. & Canada) $5.50 (Foreign)

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Arachnida. Vol. IV, No. 2. Fauna of the U.S.S.R. By B. I. Pomerantzev. Edited by George Anastos. Translated by Alena Elbl. Ready early 1959. $10.00 (U.S. & Canada) $11.00 (Foreign)

Arachnoidea. Vol. VI, No. 1. Fauna of the U.S.S.R. By A. A. Zachvatkin. Translated and edited by A. Ratcliffe and A. M. Hughes. Ready spring 1959. $10.00 (U.S. & Canada) $11.00 (Foreign)

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